29(7-9)

29(7-9)

ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS

of the

NEW YORK ZOOLOGICAL SOCIETY

VOLUME XXIX

Part 2

Numbers 7-9

AUG 1957
LIBRARY
PCFI
FISH & WILDLIFE
SERVICE

Published by the Society
The Zoological Park, New York
August 22, 1944

CONTENTS

PAGE

7. The Effects of Steroids on the Skeleton of the Poecillid Fish *Lebistes reticulatus*. By JOSEPH L. SCOTT. (Plate I) 49

8. The Function of Secondary Sexual Characters in Two Species of Dynastidae (Coleoptera). By WILLIAM BEEBE. (Plates I-V) .. 53

9. Eastern Pacific Expeditions of the New York Zoological Society. XXXIII. Pacific Myctophidae. (Fishes). By WILLIAM BEEBE & MARY VANDER PYL. (Text-figures 1-25) 59

7.

The Effects of Steroids on the Skeleton of the Poecillid Fish *Lebistes reticulatus.*

JOSEPH L. SCOTT

Department of Biology, Washington Square College of Arts and Science, New York University.

(Plate I).

The effect of the sex hormones and extracts of the anterior lobe of the pituitary upon the structure of bone has been studied by various investigators. Estrogen-treated mice, guinea pigs, pigeons and chickens have shown, upon histological study of the skeleton, an increased ossification, at least in certain regions. In order to help complete the vertebrate phylogenetic picture, the work reported here was designed to extend this study to fish. The effects of pregneninolone (Pranone, ethinyl testosterone, anhydrodroxy-progesterone) and alpha estradiol (Progynon DH) upon the skeletal structures of *Lebistes reticulatus* (Peters), a fish in which the secondary sex characters are highly responsive to these substances, were determined and are reported here. In this species, the effects of pregneninolone are purely androgenic, but in mammals this steroid substance has various other actions.

The author wishes to express his appreciation to Drs. Robert Gaunt and C. M. Breder, Jr., for suggestions and assistance. He is also indebted to Dr. Max Gilbert of the Schering Corporation for supplying the hormones used in this work. The data presented here are taken in part from a thesis for the degree of Master of Science at New York University.

Ten to fifteen fish were kept in two and a half gallon aquaria. Several plants were grown in each aquarium in an inch of sand. The temperature of the water was controlled thermostatically and ranged from 74°-78° F. Each tank was fitted with a porous stone through which was pumped a steady stream of air. Both treated and control fish were fed, daily, a diet of dried tropical fish food which was supplemented by Daphnia and Tubifex once a week.

Lebistes reticulatus, a viviparous poecillid with marked sexually dimorphic characteristics, was used as the experimental animal. In this species the anal fin of the adult male is modified to form a gonopodium, the body size of the male is normally smaller than that of the female, and the male only is brilliantly colored. The reaction of these sexually dimorphic traits of *Lebistes* to the two steroids used here have been previously described by Berkowitz (1) and Eversole (6). Since their results were fully confirmed in the course of our observations no duplicate description is given of them.

A total of 67 fish were treated. Thirty received estradiol, contained in tablets made for human oral use which were powdered and sprinkled on the water. Total dosage varied from 6.5 to 15 milligrams per tank given in equal weekly portions for periods varying from 18 to 110 days. A similar procedure was followed in treating fish with 5-milligram doses of pregneninolone, except that the effects of a single treatment were so long-lasting that monthly administration was more than sufficient to maintain masculinization of all secondary sex characters. In fact, to eliminate effective amounts of the steroid from the tanks a very thorough cleaning had to be done even six months after a dose of the compound was added to the tanks.

Histological studies were made on a segment cut transversely just caudal to the pectoral fin and between the posterior end of the body cavity and the caudal fin. The whole skeleton was studied in total mounts. The material was fixed in Bouin's fluid, washed in 70% alcohol, dehydrated by the dioxan method, and embedded in tissue-mat. Serial sections were cut at 10 microns in thickness and were stained either with Harris' hematoxylin and counterstained with eosin, or with Mallory's triple stain. Whole mounts were prepared by clearing freshly killed fish in KOH until the muscular and skeletal portions were translucent and then staining with Alizarin dye as described by Hollister (10).

Since the treatments given either masculinized or feminized the external sexual characteristics of the animals, the original sex was determined at the end of the experiment by histological examination of the gonads. These were routinely sectioned in the course of other observations. The gonad is itself affected by these treatments (1, 6),

but whether it was originally a testis or ovary was generally easily discernible by its histological appearance, the essential gametogenic elements of which were not changed. The sex ratio of the strain of fish used here is 1:1.

Observations.

I. Sexual dimorphism in the skeleton.

Cleared whole mounts of normal male and female *Lebistes* showed a skeletal dimorphic character, aside from the difference in size, only in the region of the anal fin or gonopodium (male). The skeleton which supports the anal fin of the adult female (Fig. 2) and of immature fish is composed of a group of ten separate interhaemal bones which project dorsally from the anal fin toward the haemal spines of the first three caudal vertebrae.

Three of the interhaemal bones, the second, third and fourth, are fused as one bone in the adult male (Fig. 1). In addition the first three caudal vertebrae are markedly enlarged and make a sharp angle in the direction of the three fused interhaemal bones.

Most bones in this species are made up of a central cartilaginous mass surrounded by a crust-like ossified layer. No sexual dimorphism in the histology of these structures was noted, except again in the anal fin region where the interhaemal bones of the male contained much thicker ossified layers.

II. The effects of hormones upon the skeleton.

All fish, regardless of sex, fed 5 milligrams of pregneninolone at birth, developed typical male structures precociously in the anal fin region described above. There was a fusion of four and sometimes five of the interhaemal bones in the treated animals (Figs. 3, 4, 7). This steroid caused a dwarfed condition in *Lebistes* and consequently the whole skeletal apparatus of the treated fish was reduced in size (Fig. 3). Adult females, given a single feeding of 5 milligrams of pregneninolone, all developed interhaemal bones much like the adult males (Fig. 4) within three weeks. Normal males show this skeletal dimorphism 50-60 days after birth.

Fifteen fish were fed alpha estradiol from birth. All developed a typical female anal fin with the 10 separate interhaemal bones attached (Figs. 2, 6). One group of 9 fish received 3.25 milligrams of the hormone over a period of 50 days. The male controls had begun to show a difference in the anal fin skeleton but not the treated animals. Continuing treatment until 110 days in another series did not vary results.

All of the estrogen-treated fish were studied for the effect upon ossification of the interhaemal bones. It was found in every case that there was no increase in ossification and these bones had the exact appearance of the female untreated animals (Figs. 5, 6).

On the other hand, all of the fish that were fed pregneninolone, without exception, showed an increase deposition of bone around the central cartilaginous structure of the interhaemal bones toward the condition of the adult male (Fig. 7). The first three haemal spines showed an increase in size which approached that of a normal adult male.

The supporting structures of the gonadopodium itself undergo profound changes in the course of sexual maturation in the male. These are induced precociously by pregneninolone, as described by Eversole (6).

The vertebral column was studied carefully for possible effects of hormone treatment. In all of the 67 fish treated with either hormone there was no increase in ossification or other histological changes in the vertebrae, except for the larger spines associated with the anal fin apparatus of the pregneninolone-treated fish.

Discussion.

The failure of estrogenic substances in the amounts used here to produce any effect upon ossification is conflicting with the results obtained with this hormone in higher forms. Gardner and his co-workers have reported an increase in endosteal bone formation in birds (12, 14, 15) and mice (7, 8, 24) and some increase in periosteal bone in the pigeon (25). Sutro (21) reported that there was no change in periosteal bone in estrogen-treated mice, although increases in new bone formation of the medullary cavity were noted. The changes in bone formation in rats seemed to be confined to the area round the epiphysis of the long bones, where an increase in the density of this area occurred (Day and Follis, 11). Silberberg and Silberberg (19, 20) found that both estrogens and androgens intensified the ossification of cartilage and increased the deposition of bone in the guinea pig, but that the effects of the androgens were much less intense. Perhaps an explanation for the lack of increased ossification of the estrogen-treated fish is the absence of true endosteal bone and the presence primarily of membrane bone which has been described for certain parts by Moorkerjee (16). The literature seems to reveal no information at present as to the effects of estrogens upon the membrane bones of higher vertebrates.

Pregneninolone with its androgenic action in *Lebistes*, stimulates ossification in certain of the bones of this fish. This is just the opposite of the effects produced by testosterone in birds and most mammals.

Gardner and Pfeiffer (9) and Turner and co-workers (23) found that testosterone propionate inhibited hypercalcification in the mouse and rat. In ducks, Landauer (15) reported that estrogens caused hyper-ossification even in the presence of testosterone. In view of the difference in size of the two sexes of the guppy, the female being the larger, it would be logical to expect that if sex steroids had any effect on ossification, the androgens would stimulate the process thus stopping growth. However, the well established inhibition of growth in these fish by androgens cannot be attributed to a hyper-ossification, since the latter occurs only in the region of the anal fin.

Finally, it should be pointed out that the regions of the skeleton affected by hormone treatment are exclusively those in which a normal sexual dimorphism exists. The changes induced were in character and extent parallel to that expected from the picture of normal sexual dimorphism. In other words, this fish seems to be refractory to overdosage effects and most parts of its skeleton are probably totally unresponsive to sex steroids, except in generalized size difference.

The variability and specialization in teleost fish is such that experimental results of the type reported here may be applicable only to the species in which they are observed.

Summary.

1. Most parts of the skeleton of *Lebistes reticulatus* are not responsive to either estrogenic (alpha estradiol) or androgenic (pregneninolone) sex steroids, except in size. Pregneninolone caused a reduction in skeletal size, associated with a generalized dwarfing, while alpha estradiol produced no clearly significant change in size.

2. Skeletal constituents associated with the anal fin (the gonopod in the male) differ markedly in the two sexes. This anal fin of the immature fish of both sexes is supported by a group of ten separate interhaemal bones. These bones are entirely cartilage in the young fish and in the adult female they are surrounded by a thin layer of membrane bone. In the adult male, these bones are made up of thicker portions of membrane bone than in the female and, in addition, the second, third, and fourth interhaemal bones are fused as one. The male-like condition can be fully developed by androgens in either sex and the female condition can be induced by estrogens.

No changes in the anal fin region could be induced which were greater in extent than those normally seen—that is, there were no apparent overdosage phenomena under the conditions of these experiments.

Bibliography.

1. Berkowitz, P.
1937. Effect of estrogenic substances in Lebistes reticulatus *Proc. Soc. Exp. Biol. and Med.*, **36**: 416-418.

2. . . . . .
1938. The effects of estrogenic substances in Lebistes reticulatus. *Anat. Rec.* **71**: 161-175.

3. . . . . .
1941. The effects of estrogenic substances in the fish (Lebistes reticulatus). *Jour. Exp. Zool.*, **87**: 233-244.

4. Bloom, M., W. Bloom, L. V. Domm, and F. C. McLean.
1940. Changes in avian bone due to injected estrogens and during the reproductive cycle. *Anat. Rec.* (Suppl.), **78**: 143.

5. Eversole, W. J.
1939. The effects of androgens upon the fish, Lebistes reticulatus. *Endocrinology*, **25**: 328-330.

6. . . . . .
1941. The effects of pregneninolone and related steroids on sexual development in fish, Lebistes reticulatus. *Endocrinology*, **28**: 603-610.

7. Gardner, W. U.
1940. Modification of bones of animals receiving sex hormones. *Anat. Rec.* (Suppl.), **76**: 22.

8. Gardner, W. U. and C. A. Pfeiffer.
1938. Skeletal changes in mice receiving estrogens. *Proc. Soc. Exp. Biol. and Med.*, **37**: 678-679.

9. . . . . .
1938. Inhibition of estrogenic effects on skeleton by testosterone injections. *Proc. Soc. Exp. Biol. and Med.*, **38**: 599.

10. Hollister, G.
1935. Clearing and dyeing fish for bone study. *Zoologica*, **12**: 89-101.

11. Day, H. G. and R. H. Follis, Jr.
1941. Skeletal changes in rats receiving estradiol benzoate as indicated by histological studies and determinations of bone ash, serum calcium and phosphates. *Endocrinology*, **28**: 83-93.

12. Kirschbaum, A., C. Pfeiffer, J. Van Hauverswyn and W. U. Gardner.
1939. Studies on gonad-hypophyseal relationship and cyclic osseous changes in the English Sparrow, Passer domesticus. *Anat. Rec.*, **75**: 249-264.

13. Kyes, P. and T. S. Potter.
1934. Physiological marrow ossification in female pigeons. *Anat. Rec.*, **60**: 377.

14. LANDAUER, W., C. A. PFEIFFER, W. U. GARDNER, AND E. B. MANN.
1939. Hypercalcification, -calcemia, and -lipemia in chickens following the administration of estrogens. *Proc. Soc. Exp. Biol. and Med.*, **41**: 80-81.

15. LANDAUER, W., C. A. PFEIFFER, W. U. GARDNER AND J. C. SHAW.
1941. Blood serum and skeletal changes in two breeds of ducks receiving estrogens. *Endocrinology*, **28**: 458-464.

16. MOOKERJEE, H. J., G. N. MITRA AND S. R. MAZUMDAR.
1940. The development of the vertebral column of a viviparous teleost, Lebistes reticulatus. *Jour. of Morphology*, **67**: 241-271.

17. REGAN, C. T.
1911. The osteology and classification of the teleostean fishes of the order Microcyprini. *Ann. Mag. Nat. Hist.*, 8th series, **7**: 320-327.

18. RINGEON, R.
1940. Seasonal hyperossification of the skeletal system in the female quail. *Anat. Rec.* (Suppl.), **78**: 143.

19. SILBERBERG, M. AND R. SILBERBERG.
1938. Effects of anterior pituitary implants and extracts on the epiphysis and joints of immature guinea pigs. *Arch. Path.*, **26**: 1209-1225.

20. .....
1941. Effects of hormones on the skeleton of mice, guinea pigs, and rats. *Endocrinology*, **29**: 475-482.

21. SUTRO, C. J.
1940. Effects of subcutaneous injections of estrogen upon skeleton in immature mice. *Proc. Soc. Exp. Biol. and Med.*, **45**: 151.

22. TALBOT, N. B.
1939. The effect of estrogen on the skeletal age of rats. *Endocrinology*, **25**: 325-327.

23. TURNER, H. H., E. LACHMANN, AND A. A. HELLBAUM.
1941. Effect of testosterone propionate on bone growth and skeletal maturation of normal and castrated male rats. *Endocrinology*, **29**: 425-429.

24. WENTWORTH, J. H., P. K. SMITH, AND W. U. GARDNER.
1940. The composition of bones of mice receiving estrogens and androgens. *Endocrinology*, **26**: 61-67.

25. PFEIFFER, C. A. AND W. U. GARDNER.
1938. Skeletal changes and blood serum calcium level in pigeons receiving estrogens. *Endocrinology*, **23**: 485-491.

EXPLANATION OF THE PLATE.

PLATE I.

Figs. 1 - 4, inclusive, are camera lucida drawings made from whole mounts which had been stained with Alizarin dye. They are all of the same magnification.

Fig. 1. Lateral view of the skeleton of an adult male, in the mid-body region, showing three enlarged haemal spines and the fusion of three of the interhaemal bones. These characters are typical of the mature male.

Fig. 2. Lateral view of the skeleton of an adult female, in the mid-body region, showing small normal haemal spines and ten separate interhaemal bones, typical of the adult female and the immature fish.

Fig. 3. Lateral view of the skeleton, in the mid-body region, of a female guppy fed 5 milligrams of pregneninolone from birth for a period of 21 days showing the enlarged haemal spines of the first three caudal vertebrae and the fusion of 5 interhaemal bones. These characters are typical of the adult male.

Fig. 4. Lateral view of the skeleton, in the mid-body region, of an adult female, treated with 5 milligrams of pregneninolone over a period of 21 days, showing slightly enlarged haemal spines of the first three caudal vertebrae and the fusion of the first 4 interhaemal bones. These are typical male characters.

Fig. 5. A median sagittal section of the mid-body region of an adult female 110 days old, showing separate interhaemal bones with a central cartilage portion which is surrounded by a thin sheath of membrane bone. × 100.

Fig. 6. A median sagittal section of the mid-body region of a 110-day-old male treated with 5 milligrams of estradiol from birth. The structure of the separate interhaemal bones is similar to the female control (Fig. 5). × 100.

Fig. 7. A median sagittal section of the mid-body region of a female animal treated from birth with 5 milligrams of pregneninolone over a period 21 days showing fused interhaemal bones and a thick layer of membrane bone surrounding the central portion of cartilage. × 100.

ABBREVIATIONS.

H S	Haemal spine.
F I S	Fused interhaemal bone.
A N T	Anterior end of skeleton.
R	Radial bulbous portion of the anal fin to which are attached the fin rays.
I S	Interhaemal bone or spine.
C	Cartilage.
B	Membrane bone.

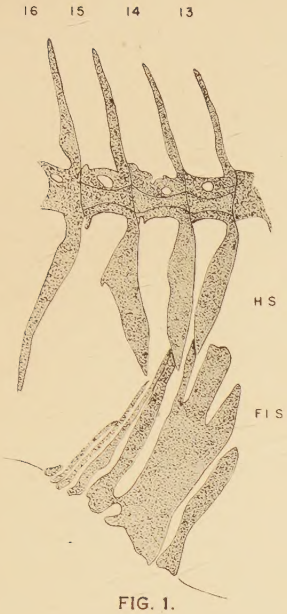


FIG. 1.

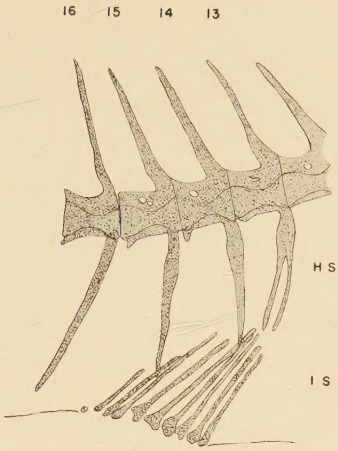


FIG. 2.

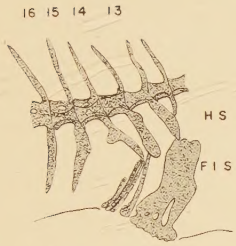


FIG. 3.

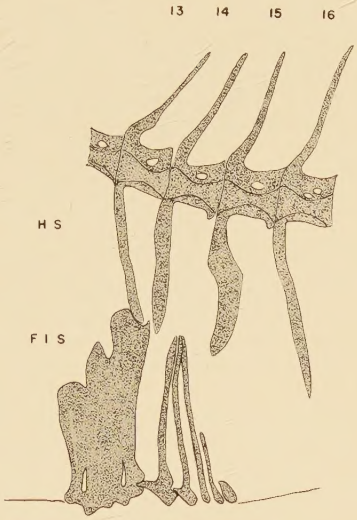


FIG. 4.

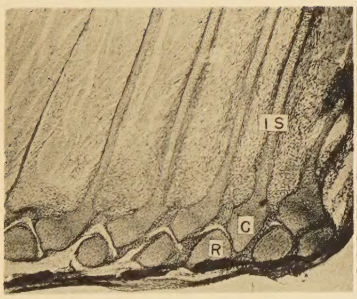


FIG. 5.

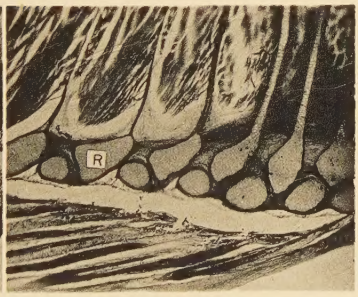


FIG. 6.

FIG. 7.

THE EFFECTS OF STEROIDS ON THE SKELETON OF LEBISTES RETICULATUS.

Digitized by the Internet Archive
in 2025

https://archive.org/details/zoologica-nyzs_1944_29_7-9

8.

The Function of Secondary Sexual Characters in Two Species of Dynastidae (Coleoptera).[1]

WILLIAM BEEBE.

Director, Department of Tropical Research, New York Zoological Society.

(PLATES I-V).

[This is a contribution from the Forty-third or Venezuelan Expedition of the Department of Tropical Research of the New York Zoological Society made under the direction of Dr. William Beebe. The expedition was sponsored by grants from the Committee for Inter-American Artistic and Intellectual Relations and from four trustees of the Zoological Society, George C. Clark, Childs Frick, Laurance S. Rockefeller and Herbert L. Satterlee, and by invaluable assistance from the Standard Oil Companies of New Jersey and Venezuela. For maps and ecological data see *Zoologica*, Vol. XXVIII, No. 9, pp. 53-59, 1943.]

These notes have to do with two species of dynastids, *Megasoma elephas* Fabr., 1775, and *Strategus aloeus* Linnaeus, 1758. The Venezuelan name for these beetles is *Tornador*, the borer. Another name is *Congarocho*, and in the Andes they are known as *Bobute*.

These so-called elephant beetles were observed and collected at Caripito, northeastern Venezuela, in the course of the Forty-third Expedition of the Department of Tropical Research of the New York Zoological Society, during a period of seven months, from February to September, 1942. The photographs, both stills and motion-pictures, were taken by Miss Jocelyn Crane, Research Zoologist on the staff of the department.

Only once did I find the big *Megasoma* and the smaller *Strategus* under normal conditions. On March 18 a female of the latter was observed crawling up the trunk of a small jungle tree, and a few days later two male *elephas* were discovered resting beneath an overhanging branch, on a half-rotten log, quite hidden from view.

On March 20 I found a female *Strategus* in a spider web of unusual strength and size, the large rufous-bodied owner frantically wrapping up the struggling beetle. On the same day, a half-mile away, a member of my staff came across an identical occurence, only here the victim was a male. All others of both species were taken when flying at night against the screened windows of the laboratory, or around the electric lights in the compound, or on the ground on their backs, in early morning, within the radius of the same lights. Their appearance, however, was only during or after a rain. Fewer than fifty of each species were taken during our whole stay. In *Megasoma* the sexes seemed about equal, but *Strategus* females dominated almost six to one. From the beginning of the rains on April 27, both species became more abundant, several often being taken close together in the mornings beneath the lights of the refinery. None were seen after July 12.

Thg great development of horns of varying sizes and shapes on the head and thorax of male beetles of the family Dynastidae has long attracted attention and excited speculation. These specialized structures in connection with the great size of the beetles are reflected in many technical names: *Dynastes, Megasoma, Megaceros, Goliathus, elephas, hercules, rhinoceros, atlas,* etc.

Charles Darwin in 1871, in the first edition of "The Descent of Man," (Vol. I, pp. 371-372) wrote as follows:

"The extraordinary size of the horns, and their widely different structure in closely-allied forms, indicate that they have been formed for some important purpose; but their excessive variability in the males of the same species leads to the inference that this purpose cannot be of a definite nature. The horns do not show marks of friction, as if used for ordinary work. Some authors suppose that as the males wander much more than the females, they require horns as a defence against their enemies; but in many cases the horns do not seem well adapted for defence, as they are not sharp. The most obvious conjecture is that they are used by the males for fighting together;

[1] Contribution No. 689, Department of Tropical Research, New York Zoological Society.

but they have never been observed to fight; nor could Mr. Bates, after a careful examination of numerous species, find any sufficient evidence in their mutilated or broken condition of their having been thus used . . . The conclusion, which best agrees with the fact of the horns having been so immensely yet not fixedly developed,—as shown by their extreme variability in the same species and by their extreme diversity in closely-allied species—is that they have been acquired as ornaments. This view will at first appear extremely improbable; but we shall hereafter find with many animals, standing much higher in the scale, namely fishes, amphibians, reptiles and birds, that various kinds of crests, knobs and horns have been developed apparently for this sole purpose."

Eight years later, Alfred Russel Wallace in "Tropical Nature" (p. 372) writes of the "immense horns of some beetles of the families Copridae and Dynastidae, which Mr. Darwin admits are not used for fighting, and therefore concludes are ornaments, developed through selection of the large-horned males by the females. But it has been overlooked that these horns may be protective. The males probably fly about most, as is usually the case with male insects; and as they generally fly at dusk they are subject to the attacks of large-mouthed goatsuckers and podargi, as well as insect-eating owls. Now the long, pointed or forked horns, often divergent, or movable with the head, would render it very difficult for these birds to swallow such insects, and would therefore be an efficient protection, just as are the hooked spines of some stingless ants and the excessively hard integuments of many beetles, against the smaller insectivorous birds."

Passing by some other comfortingly easy explanations we come to the antithesis, given for what it is worth at third hand in "A Year of Costa Rican Natural History" by A. S. and P. P. Calvert (1917). The authors write (p. 69), "Dr. Ohaus has also kindly informed us that a correspondent of his friend Herr Nagel has observed, in Venezuela, that the males of *Dynastes hercules* fight very violent battles among each other for the females; that they seize and crush with the cephalic and prothoracic horns, the weaker male often having its thorax and elytra crushed, and that the victorious males take the females between the horns and carry them away." This anonymous information coming to us through three subsequent channels requires, I think, considerable confirmation, especially as to the direct crushing power of the horns and the ultimate use of these structures in the Sabine-like kidnapping of the female.

In these and numerous other contributions we have a number of suggestions as to the use of these horns: ornaments, direct defence against attacks from enemies, and indirect in making ingestion by large-mouthed assailants difficult or impossible, transportation of the female, overdevelopment as sheer, useless impetus of secondary sexual characters, scraping and puncturing bark to induce the flow of edible sap, and fighting among themselves for the possession of the female.

Although I have often kept these giant beetles in vivaria in the tropics, I have never seen, either in free or captive specimens, any confirmation of any of these suggested uses of the horns until April 13, 1942, in the Zoological Society's laboratory at Caripito, northeastern Venezuela.

For a fortnight I had kept three males and a female *Megasoma elephas* in a glass battery jar. The quartet of big beetles had fed steadily on over-ripe banana, their method of feeding being to push and nuzzle into the soft pulp until they were quite plastered with the fruit. In a general cleaning of laboratory cages on this 13th of April I carried the jar and its contents to an outside faucet and held one beetle after another beneath the swift stream of water. When picked up, as usual they turned and twisted, the tearing power of their sharp claws and the pinching strength of head armor against the edge of the thorax making it difficult and painful to hold them. During the process of washing they became quiet and did not move a leg again until returned to their cleansed cage.

I returned the jar to its place, gave the beetles a supply of fresh banana and forgot them until a half-hour later when I heard a confused sound. I found the food neglected and the three males in an intricate pile, massed around the female. I removed her and from this moment on the battling of the males among themselves occupied considerable of our attention. Food was completely ignored in the newly aroused heat of battle. When from exhaustion or other cause the combative instinct died down, I could always initiate new and violent encounters by either an application of the water treatment, or the introduction of a female. Two or three days of enforced drought would reduce the war to casual skirmishes, ineffectual feints, and a renewed interest in the mushy fruit. It seemed more than a coincidence that on April 27, only fourteen days after the transformation wrought by the artificial deluge of the water faucet, the actual rainy season began. In my precocious breaking of the dry season I had anticipated the effect of the annual rains in unlocking the reproductive reactions of these great insects.

Concomitant with this suddenly aroused combativeness was nocturnal activity. From now on we were constantly disturbed by loud drummings and reverberations from the beetles, and found that from dark to

midnight both males and females sought to escape from their cages by flight. The loud banging was due to the impact of the spread elytra against glass and wire, driven by the powerful vibration of the flight wings. This activity ended about twelve or one o'clock and for the rest of the night the beetles rested quietly or fed.

MATING OF *Megasoma elephas:* After being drenched with water a pair of beetles would mate almost immediately, whether after long confinement together during which their chief interest was in the banana fodder, or whether both insects had been just caught and placed together. There was no hint of preliminary courtship, no opportunity for appraisal of the horns as ornaments by the female or sexual selection. If no rival was present, the male went straight for the relatively small female and when within reach hauled her toward him, and mating took place at once.

When the male first mounts he wraps his fore legs around the female, sliding them into the lateral crevice between the armor of her head and thorax. In this grip he makes no use of tarsi and terminal claws, but only of the stout, spiny tibia. The second pair of legs hook underneath her body on to the bases of her legs, the terminal claws functioning in this case. When copulation is attained his position changes radically. He now rears almost straight upright, his whole body becoming vertical, resting on his rear tarsi, with the front pair of legs and often the second dangling in the air above the back of the female.

This identical procedure was followed in the first three matings and in a fifth. In the fourth, between a newly caught female and the same male in mating number two, the finale was slightly varied. While the male was in quite as vertical a position, he had shifted the hold of his fore legs, which now clung by the terminal claws of the tarsi to the basal joints of the forelegs of the female, while both second and third pairs of legs dangled free in mid-air. This resulted in a triangular support; his juncture with the female plus the backward pull with his forelegs.

After the water treatment, even if a male was half-immersed in a banana, if a female was dropped into the cage, he instantly became aware of her and rushed in her direction. If a male was substituted the feeding male made no mistake, but, slimy banana and all, went for the new-comer and engaged him head on. In nervousness and quickness his reactions speeded up one hundred per cent. His ordinary activity is a heavy crawling, a slow, bungling creeping with the body dragging. When preparing to mate or fight the body is raised clear and the movements are quick and dynamically directed. In the preliminaries of both activities there is often a series of rhythmic jerks.

EGGS: On May 23 we noticed in the cage which contained five *Megasoma* females that the detritus was in the form of small, rounded balls of dark-colored material, although there was nothing in the enclosure but sections of over-ripe banana. In two cages containing males the excreta was nothing but formless masses of food. I dissolved several of the balls but found no trace of eggs. On May 25, however, Miss Crane discovered the first egg lying loose on the bottom, and after this several appeared every day, but with no relation to the rounded masses of material. Decayed logs put in with the females aroused no interest whatsoever. The eggs measured 4 by 4.7 mm., the surface being smooth, and ivory white.

FIGHTING OF *Megasoma elephas*: Although the battle between each individual pair of male beetles is, to a certain extent, slightly different from every other, yet there are several fundamental phases which seem invariable. The opponents meet head on, and either warily wait for the other to attack, or one may rush headlong and begin the encounter. Usually both wait and spar at a little distance. The object first noticeable is an attempt with one or both fore tarsi and claws to trip and unbalance the opponent. This is evident in a long series of single photographs and in several complete kodachrome motion picture sequences. There are quick forward lunges and reachings out with one or both legs, sometimes at the same moment by both insects. This may or may not succeed, but one will force the fighting and the result may be straight pushing and butting for a considerable period, exactly like two antlered deer. Now and then an effort will be noticed to lower the head and get the cephalic horn beneath the other insect. Again and again this is tried, and both may attempt it at the same moment. Then recur the rearing and tripping attempts.

Periods of rest or waiting may intersperse the encounter and twice I have seen one beetle turn and rush after the female. In both cases the other was after him full speed and the battle began again. The female never remained, but went off as far as the confines of the cage, or in the case of the fight taking place in the open, as far as we would allow her to go, when we would recapture her for fear of losing her in the underbrush. The only certainty was that she showed not the remotest interest in the encounter or in either of her suitors. In all our experience with these beetles, which was invariably in the daytime, we never saw either sex take to wing.

Unexpected phases often interrupt the regular succession of the happenings I have

mentioned. The pull of the sharp, curved claws often unbalances both beetles at once and they lose their footing and roll over and over, all twelve legs tangled together and entailing considerable awkward effort before they separate and face each other again. It is astonishing how loud the clash of horn against horn becomes when one's ear is close to the fighters. The insects are usually horizontal when they begin pushing against each other, but attempts at tripping will cause both to rear up high on the second and third pairs of legs. Then, if at all, comes the final phase, the all out attempt to get the tip of the curved bifurcated horn caught in the soft skin of the ventral joint between the thorax and abdomen. Once secured, we realize this is evidently the chief object of the encounter. The successful one puts forth all the strength of which he is capable and lifts again and again with all his might. The higher the other is lifted the more helpless he becomes as his feet, one after the other, leave the ground, and with several super-beetle flings the victim of this grip is thrown over on to his back. Not once, but again and again this was the end result. Often the beetle simply rolled over and came back on his feet again and the whole engagement recommenced, but sometimes he landed on his back and if the surface was at all level and smooth, he spun helplessly waving all six feet in mid-air. The winner began searching in all directions, evidently for the female. Yet if replaced by himself in a cage he soon settled down to immobility.

The whole encounter was reminiscent of the broomstick or cane encounters of our childhood's parties, where the hands of two boys were tied and a cane inserted behind knees and above elbows and the ensuing encounter was, by manipulation of the ends of the stick or otherwise, to roll the opponent over on his back, when he became as helpless as an upset beetle.

The Middleweight Elephant Beetles (*Strategus aloeus*) fought as readily as their larger relations and in almost exactly the same manner. An important difference between the two species is that *Strategus* has all three horns on the thorax, while *Megasoma* has the central curved horn on the head itself. Although thus denied the inter-mobility of the horns, the smaller beetles fought with equal fury and quite as satisfactory results. The general plan of battle was identical, to get the anterior horn beneath their opponent and lever him up and over. In one of the first fights watched there were several momentary lockings and once the attacker was himself pried into the air and almost on his back. When upside down this species seemed even more helpless than the larger, and I believe would die of starvation on a smooth surface if left to themselves. The general movement and activity was less evident owing to the lack of separate play of horn number one, but there was no lack of fierce effort.

These accounts have been general ones. The following are notes which I took on two individual encounters:

On April 13 two *Megasoma* males after showing desire for battle were placed by themselves in a large open space and they instantly began fighting. They were the two largest of the three which had been kept together for two previous weeks and during that time had, as I have said, shown no great interest in each other or the female, concentrating solely on resting and feeding. This fight was short. The two rushed together and the horns met with a distinct click. For three minutes they pushed, bracing their feet with all possible power. Then separating they did it all over again. The larger one of the two seemed to have the advantage and after three attempts inserted his horn beneath the body of his adversary and actually tossed him clear of himself and the ground. In this case he was on top of the beetle before he could right himself or attempt to do so, and in the ensuing maze of waving legs, the successful male was almost overcome. Again he upset the smaller and again he foolishly helped him to his feet by rushing upon him. At the third and last upset I distinctly saw the horn of the larger beetle push and tear the membrane of the ventral joint, and examination confirmed this damage, slight though it was. A stalemate of pushing ensuing, I separated them for the night.

Disparity in size both between individual males and also sexually is very marked in *Megasoma*. An average male weighs 32 grams and a female 24 grams. The males vary between weights of 28 grams and 36 grams, with corresponding total lengths of 85 mm. and 103 mm. When a number of males are compared they seem to fall into two general nodes to which we gave the names of Major and Minor.

For several days a female and a minor male had been confined together and they had mated. I introduced a major male on May 21, and after righting himself he clambered awkwardly over the small male and toward the female. His antennae played over her back for a few seconds and then the lesser male blundered past him. Like a flash the major turned on the other beetle and the fiercest fight we had seen thus far was on. Both of course tried to get the curved horn under the other, both tried to trip the other off balance. Three times Minor was actually tossed into the air and landed on his back. He levered himself upright and

after the third event he seemed to become thoroughly aroused and fought twice as hard as before. His very smallness of size was a help in some ways and the locked horn gave the larger insect little advantage. Once the giant was turned over and fell on the female and instantly the minor rushed at both and while they were tangled, butted and drove against them and rolled them about. The larger finally got his opponent in a corner and hooked and twisted violently, securing some strange, secure lock and after a wrench we saw the right middle leg of the smaller beetle break off near its base and lie kicking by itself on the ground. Not for a moment did the injured beetle stop his efforts, but I now retrieved him. The same five-legged minor on the following day mated without trouble with two freshly caught females.

After removing the wounded beetle I substituted another major and the combat went on. Both beetles met head on and for at least three minutes, pushing and twisting and jerking with all their might, neither could apparenly break the lock. It was like two deer whose antlers have sprung together beyond all possibility of breaking apart. I separated the beetles and found that the apparent locking was due only to uninterrupted pushing, and that in reality the two beetles were quite free to move apart whenever one of them should relax his efforts.

As I said earlier, I neither anticipated nor saw any attempt at carrying the female, and in fact we were unable to push the large-bodied female between the three horns even temporarily, so that such an improbable feat, as reported in *Dynastes hercules*, seems impossible in the present species.

Even at the height of violent combative activity, I saw no possibility, either in their encounters or in my handling, of any sufficient direct force strong enough to crush or fracture the extremely hard body or elytral armor. The only injuries observed were the slight tearing of the intra thoracic and abdominal ventral membrane, and the snapping of a leg by oblique leverage.

The succession of still photographs of live, unposed beetles taken in two-hundredths of a second presents fairly satisfactory visual realization of this phase of activity of these giant beetles. Proper appreciation of the quickness of movement, the un-scarab swiftness and deftness of use of legs and horns can only be had from the kodachrome motion pictures of the entire conflicts.

SUMMARY: Male beetles of two species of Dynastidae, *Megasoma elephas* and *Strategus aloeus*, use their cephalic and thoracic horns for fighting with each other.

The initial stimulus is the beginning of the rainy season. Nocturnal and mating activity are consequent upon individual rains. In captivity both can be aroused to highest pitch and culmination by artificial applications of water.

The phases or methods in fighting in both species are identical, first an attempt to unbalance the opponent by tripping, and then by ventral attack with the anterior horn to lift and throw him upon his back.

EXPLANATION OF THE PLATES.

These fourteen photographs supplement the verbal portion of this paper, and take the place of the kodachrome motion picture sequences which are limited to a screen. The individual beetles are the same throughout, but three photographs have been interpolated from second and third encounters between the same contestants. These fourteen are selected from a total of sixty-nine. All were taken by by Miss Jocelyn Crane.

The battle took place in the compound of the laboratory at Caripito, Venezuela. *Photographic data:* camera, Leica; lens, Leitz 90-mm. Elmar; film, Eastman Super-XX. Figs. 1-7 were made by sunlight alone, exposure 1/60 sec., f:12.5; figs. 8-14 by synchroflash, exposure 1/200 sec., f:16.

A male elephant beetle, *Megasoma elephas* approaches a female (Figs. **1** and **2**). While he prepares to mate, a second male approaches (Figs. **3** and **4**). The new arrival attacks (Fig. **5**) and separates the mating pair (Fig. **6**). The beetles meet head on (Fig. **7**) and in their efforts to trip each other, rise on their second and third pairs of legs (Fig. **8**). As frequently happens, the tripping is mutually successful and both are upset (Fig. **9**). They separate at once. In the course of the continued battle the first male succeeds in getting his cephalic horn beneath the head of his opponent (Fig. **10**), and exerting all his strength lifts again and again, raising the beetle clear off his feet (Figs. **11** and **12**), and rolling or throwing him over (Fig. **13**). With the interfering beetle helpless on his back, beetle number one begins his search for the female (Fig. **14**).

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

THE FUNCTION OF SECONDARY SEXUAL CHARACTERS IN TWO SPECIES OF DYNASTIDAE (COLEOPTERA).

FIG. 5.

FIG. 6.

FIG. 7.

THE FUNCTION OF SECONDARY SEXUAL CHARACTERS IN TWO SPECIES OF DYNASTIDAE (COLEOPTERA).

FIG. 8.

FIG. 9.

FIG. 10.

THE FUNCTION OF SECONDARY SEXUAL CHARACTERS IN TWO SPECIES OF DYNASTIDAE (COLEOPTERA).

FIG 11.

FIG. 12.

THE FUNCTION OF SECONDARY SEXUAL CHARACTERS IN TWO SPECIES OF DYNASTIDAE (COLEOPTERA).

FIG. 13.

FIG. 14.

THE FUNCTION OF SECONDARY SEXUAL CHARACTERS IN TWO SPECIES OF DYNASTIDAE (COLEOPTERA).

9.

Eastern Pacific Expeditions of the New York Zoological Society. XXXIII. Pacific Myctophidae. (Fishes).[1]

WILLIAM BEEBE & MARY VANDER PYL.
Department of Tropical Research of the New York Zoological Society.

(Text-figures 1-25).

(This is the Thirty-third of a series of papers dealing with collections of the Eastern Pacific Expeditions of the Department of Tropical Research of the New York Zoological Society, made under the direction of William Beebe. The present paper is concerned with specimens taken on the *Arcturus* Oceanographic (1925), the Templeton Crocker (1936), and the Eastern Pacific *Zaca* (1937-1938) Expeditions. For data on localities, dates, dredges, etc., of these expeditions, refer to *Zoologica*, Vol. VIII, No. 1, pp. 1 to 45 (*Arcturus*); Vol. XXII, No. 14, pp. 33 to 46 (Templeton Crocker), and Vol. XXIII, No. 14, pp. 287 to 298 (Eastern Pacific *Zaca*).

CONTENTS.

PAGE
Introduction 59
Myctophidae collected by the Eastern Pacific Expeditions 61
Myctophum affine (Lütken) 61
Myctophum aurolaternatum Garman 64
Myctophum californiense Eigenmann & Eigenmann 66
Myctophum coccoi (Cocco) 67
Myctophum evermanni Gilbert 73
Myctophum laternatum Garman 74
Myctophum pterotum (Alcock) 75
Myctophum rarum (Lütken) 76
Myctophum reinhardti (Lütken) 77
Myctophum valdiviae Brauer 78
Lampanyctus elongatus (Costa) 79
Lampanyctus idostigma Parr 81
Lampanyctus longipes (Brauer) 81
Lampanyctus macdonaldi (Goode & Bean) 82
Lampanyctus macropterus (Brauer) 82
Lampanyctus mexicanus (Gilbert) 84
Lampanyctus omostigma Gilbert 85
Lampanyctus ritteri Gilbert 86
Lampanyctus tenuiforme (Brauer) 87
Lampanyctus townsendi (Eigenmann & Eigenmann) 87
Diaphus dumerili (Bleeker) 88
Diaphus gemellari (Cocco) 89
Diaphus pacificus Parr 90
Diaphus rafinesquii (Cocco) 90
Bibliography 91

INTRODUCTION.

This paper is concerned with the Eastern Pacific *Myctophidae* taken off Mexico, Central America and the Galápagos on the Seventeenth, Thirty-fifth and Thirty-eighth expeditions of the Department of Tropical Research sent out by the New York Zoological Society.

The Seventeenth or *Arcturus* expedition in 1925 was in the Pacific for 83 days, during which time 314 deep-sea hauls were made. The area covered extended from the Gulf of Panama to Cocos Island and the Galápagos, this general area being traversed four times on two round trips. The Thirty-fifth or *Templeton Crocker* expedition in 1936 was of 59 days' duration, and 55 hauls were made along the west coast of California, out to Clarion Island, and from Mazatlan half way up the Gulf of California. The last, *Zaca*, or Thirty-eighth trip in 1937-1938, lasted 145 days. Twenty-seven deep-sea hauls were made from Lower California south along the coast of Mexico and Central America to Gorgona Island. In the course of these three expeditions 10,575 fish of the family Myctophidae were captured, and these resolved into 24 species.

In 1939 Dr. Rolf L. Bolin wrote "A Review of the Myctophid Fishes of the Pacific Coast of the United States and of Lower California." I quote from him, "The area treated in this report is a semicircular segment of the North Pacific Ocean approximately 1,000 miles in radius, having its center a little east of Point Conception, California, and extending from Cape Flattery, Washington, to Cape San Lucas, Lower California, including the Gulf of California."

Within this area Bolin records 20 species of myctophids, derived from various collections and museums (Bolin, 1939). One of these, *Scopelengys tristis*, I hesitate on known evidence to admit within the family Myctophidae. Of the remaining 19, 12 species occur in our collections. All of the remaining seven which we did not capture, appear to be essentially northern forms, none having been taken south of 31° 33′ N. Lat., or the boundary between California proper and Lower California. This is also the northern limit of our collecting.

The seven northern species in Bolin's list and not in ours are, *Electrona crockeri*, *Tarletonbeania crenularis*, *Diogenichthys scofieldi*, *Lampanyctus leucopsarus*, *Lampanyctus nannochir*, *Lampanyctus steinbecki* and *Lampanyctus regalis*.

The deep-sea family of lanternfishes or Myctophidae appears to be second in abun-

[1] Contribution No. 690, Department of Tropical Research, New York Zoological Society.

dance among all other abysmal fish. In my "Preliminary List of Bermuda Deep-sea Fish" (Beebe, 1937) I recorded the fact that the 57 species of Myctophidae composed about 25 per cent. of the entire list of deep-sea species, while the total count of specimens, amounting to about 12,000, was 10 per cent. of the entire catch.

This family was exceeded only by that of the genus *Cyclothone* of the family Gonostomidae, which, with only three species or 1 per cent. of the whole, in individuals amounted to nearly 94,000 or 82 per cent.

In the Pacific, proportions of actual numbers are of no comparative value, owing to the fewer number of hauls (396 compared with 1,500), much shorter time involved, and a widely scattered area compared with a concentration within an eight-mile circle.

On the three Pacific expeditions I took 10,575 myctophids of 24 species, whereas cyclothones were obtained in relatively much fewer numbers than in the Atlantic. The relation between myctophids, cyclothones and other bathypelagic fish in the two oceans as represented in the catches on my expeditions are clearly shown in the accompanying diagrams. (Text-fig. 1).

	Atlantic	Pacific
Myctophids	10,008	10,575*
Cyclothones	95,189	15,500
Other fish	10,550	2,200
Totals:	115,747	28,275

As to specific abundance in the two oceans, in the Pacific *Myctophum coccoi* (4,466) is far ahead, with *M. affine* next (3,708), and *M. laternatum* third (1,171). In the Atlantic, *M. laternatum* is first (2,853), and *M. benoiti* second (1,294). *M. coccoi* and *M. affine* are well down the list.

* Out of this total, 4,460 were *coccoi*, all taken on the *Arcturus*, as compared with 165 taken in Bermuda.

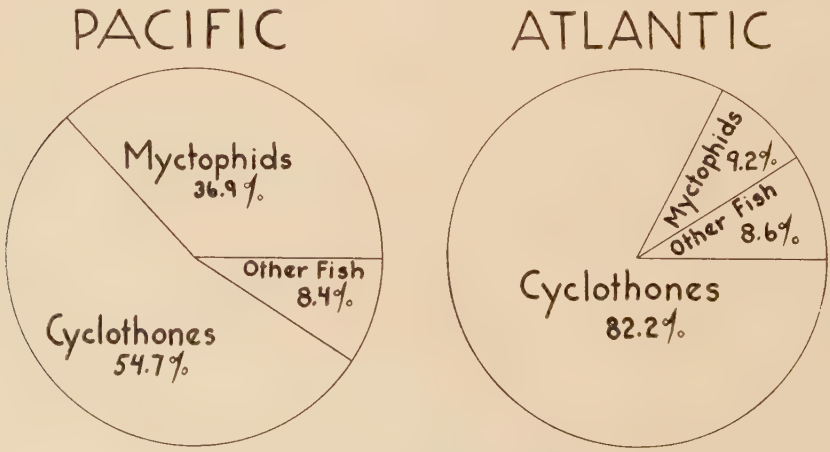
On the Templeton Crocker expedition the southern limits were Clarion Island, Cape San Lucas and Mazatlan. In 55 hauls we took 346 myctophids of eight species, all of which were collected on one or both of the other trips. Two species (*M. laternatum* and *L. mexicanus*) out of the seven, comprised 89 per cent. of the whole.

On the *Zaca* trip which included the whole of Lower California and south to Gorgona Island, in the course of 27 hauls, 621 myctophids were captured, of 15 species. Here again, two species (*M. laternatum* and *L. omostigma*) predominated, and formed 86 per cent. of the entire catch. Four species (*M. pterotum, L. idostigma, Diaphus dumerili* and *D. pacificus*) were not taken on the other trips.

On the *Arcturus* trip which was concentrated in the comparatively limited area between Panama and the Galápagos, 314 hauls yielded 9,608 individual myctophids, resolving into 19 species. For the third time, two species (*M. affine* and *M. coccoi*) were so abundant that they totalled 84 per cent. Nine species (*M. rarum, M. valdiviae, L. elongatus, L. longipes, L. macdonaldi, L. macropterus, L. tenuiforme, L. townsendi,* and *D. gemellari*) were confined to the hauls of this expedition.

In regard to the general distribution of the 24 species taken by us, 14 are cosmopolitan (*M. affine, M. coccoi, M. laternatum, M. pterotum, M. reinhardti, M, valdiviae, L. elongatus L. longipes, L. macropterus, L. tenuiforme, L. townsendi, D. dumerili, D. gemellari* and *D. rafinesquii*). Three of these have a restricted distribution in the Pacific (*L. longipes,* and *D. gemellari* only in the Galápagos, and *M. valdiviae* only in Japan and the Galápagos).

Eight more species have so far been found only in the Pacific. Five of these are limited to the Eastern Pacific (*M. aurolaternatum,*



Text-fig. 1. Relative percentages of deep-sea myctophids, cyclothones and other bathypelagic fish taken in the Pacific and in the Atlantic.

L. mexicanus, L. idostigma, L. ritteri, and *D. pacificus*). One reaches Hawaii (*L. omostigma*), and two extend as far as the western boundary of this ocean (*M. californiense* and *M. evermanni*).

The remaining two myctophids have the rather curious distribution of Galápagos and the Atlantic (*L. macdonaldi* and *M. rarum*).

These facts must always be held suspect and tentative from the fragmentary knowledge which is implied by the necessarily sporadic character of the results of deep-sea trawling.

A few facts may be gleaned from the record of breeding females and the total number of eggs ready to be deposited. The height of the breeding season seems to be about June 1, with scattered instances from May 11 to 25 and more rarely as early as April 12. I have no notes between July and November.

Graded on number of ripe eggs we have the following list of selected examples:

Total Eggs	Diameter mm.	Length Female mm.	Species
120	.28	22	*Myctophum valdiviae*
400	.45	25	*Myctophum laternatum*
1200	.3	55.5	*Myctophum affine*
2400	.27	76	*Myctophum aurolaternatum*
2700	.28	59	*Lampanyctus omostigma*
3300	.25	50	*Myctophum coccoi*

Correlation of number of eggs with size of female seems the only outstanding fact, and to a less degree a relation between the total eggs and their relative diameter.

One feature which I hope will be of service to future workers in the field of Pacific myctophids is the brief annotation of data from the various bibliographies, which has been painstakingly excerpted by the junior author.

In the present study, the criterion of adulthood is based on the presence of luminous glands combined with relative size and other superficial external characters. This method necessarily includes many slightly immature individuals which, if classified as in my previous deep-sea papers, would have been considered "transitional adolescents," since in those the term "adult" was reserved for individuals which were found on dissection to have mature gonads. This simplification of the usual growth stage analyses into merely "young" and "adult" was necessitated by present practical difficulties in examining in greater detail such large numbers of specimens. Numerous post-larval and other extremely immature myctophids lacking all photophores were not included in this study.

By "length" is always understood standard length, measured from the tip of the snout to the end of the vertebral column at the base of the caudal fin.

Abbreviations of trawling apparatus are as follows: T=ordinary meter net; Pt=Petersen trawl; Ot=otter trawl; L=surface light.

WILLIAM BEEBE

TABLE I.

NUMERICAL TABULATION OF SPECIES COLLECTED ON THE THREE EXPEDITIONS TREATED IN THIS PAPER.

Species	Arcturus	Templeton Crocker	Zaca	Total
Myctophum affine	3,675	1	32	3,708
aurolaternatum	113	3	9	125
californiense	...	5	8	13
coccoi	4,460	3	3	4,466
evermanni	105	...	3	108
laternatum	617	129	425	1,171
pterotum	...	...	6	6
rarum	1	...	...	1
reinhardti	131	24	1	156
valdiviae	35	...	...	35
Lampanyctus				
elongatus	3	...	...	3
idostigma	...	...	12	12
longipes	1	...	...	1
macdonaldi	3	...	...	3
macropterus	137	...	...	137
mexicanus	36	177	4	217
omostigma	246	...	94	340
ritteri	19	...	1	20
tenuiforme	5	...	...	5
townsendi	1	...	...	1
Diaphus pacificus	...	...	19	19
dumerili	...	...	3	3
gemellari	1	...	...	1
rafinesquii	19	4	1	24
Totals:	9,608	346	621	10,575

MYCTOPHIDAE COLLECTED BY THE EASTERN PACIFIC EXPEDITIONS.

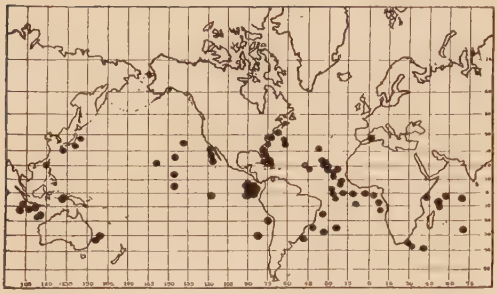
Myctophum affine (Lütken, 1892).

Specimens taken by Eastern Pacific Expeditions: 3,675 specimens; *Arcturus* Oceanographic Expedition; surface to 800 fathoms; between 2° 00′ S. and 6° 58′ N. Lat., and 83° 34′ and 91° 53′ W. Long.; lengths 15 to 67.5 mm.; between March 31 and June 19, 1925.

1 specimen; Templeton Crocker Expedition; at the surface; 25° 02′ N. Lat., and 115° 52′ W. Long.; length 22 mm.; May 19, 1936.

32 specimens; Eastern Pacific (*Zaca*) Expedition; surface to 500 fathoms; between 4° 30′ and 28° 42 N. Lat., and 78° 35′ and 117° 50′ W. Long.; lengths 6 to 66 mm.; between Nov. 8, 1937, and March 25, 1938.

Specimens previously recorded: 296 specimens; ? to 96 mm.; 0 to 1,914 fathoms; north and south Atlantic, Mediterranean, Indian Ocean, Japan, East Indies, Tasman Sea, Hawaiian Islands, central and eastern Pacific from lower California to Chile.



TEXT-FIG. 2. Distribution of *Myctophum affine.*

Photophore count and variation: 42 males, 21 females and 421 young fish examined as to relative number of photophores on both sides of the body. The mean is very evidently 8-5 on both sides of the body, as 221 out of the 484, or 45.6 per cent., possess this combination. The extremes in numbers are 6-9 and 4-6. Parr in counts on Atlantic specimens found as many as 10 in the anterior, and as few as 3 in the posterior AO.

In addition to the dominant pattern of 8-5, only seven other numbers are found which show symmetrical lateral distribution, 7-4, 7-5, 7-6, 8-4, 8-6, 9-4 and 9-5. The remainder fall irregularly into a total of 31 variations on the two sides. The three groups show no age or sexual differences in total numbers or in variations of photophores.

Luminous glands: The youngest fish in which traces of male, supracaudal luminous glands are visible, measures 29 mm., and shows two glands. The youngest female with glands showing is 34.5 mm. in length, and also has two glands. The largest male, 66 mm., has seven glands, and the largest female of 67.5 mm. possesses four glands. This gradual increase in both sexes with age, is confirmed by five-millimetre successive averages as follows: males, from 29 to 66 mm. 2, 3.2, 3.6, 3.8, 4, 5, 5.5 and 7 glands; females, from 34.5 to 67.5 mm. 2, 2.15, 2.25, 3 and 4 glands.

Three specimens taken on the *Arcturus* expedition (Cat. Nos. 5281, 5281a and 6059; lengths 44, 54.5 and 59 mm.) show both supra- and infracaudal luminous glands. The first shows an unusually small number of photophores, viz: 7-5, 7-5; and the third fish possesses almost the highest number, 9–5, 9–6. No. 5281 shows two dorsal and two ventral glands, No. 5281a has two dorsals and three ventrals, and No. 6059 has two dorsal and five ventral glands.

Sex proportions: Out of the total of 3,708 specimens collected, 63 are adult; 42 males and 21 females, a proportion of two to one.

Breeding: Two egg counts are as follows: Female No. 5281c, length 51.5 mm.; taken April 12, off Galápagos; total egg count, both ovaries ca. 1,400, eggs measuring .34 mm. in diameter. Female No. 6058b, length 55.5 mm.; taken June 1, off Cocos Island; total eggs ca. 1,200; .3 mm. in diameter.

Anatomy: Typical adult male, No. 6058a, taken with above female (No. 6058b) and two young at Station 74, surface haul T-35. Length 54.5 mm.; air bladder large, 14.5 by 4.5 mm.; stomach heavily pigmented with black, 7.5 by 2.2 mm. (for food see separate section). The pyloric opening surrounded, at a distance of 3 mm. along the gut, by 9 caeca, which measure from 3 by .8, to 4.5 by 1.1 mm.

The intestine has but one convolution to break the straight line from the point at which the caeca enter it to the anal opening; total length 20 mm. The testes measure 13 by 1.5 mm. and lie along the ventral side of the air bladder. The kidney occupies the space between the slightly pigmented lining of the body cavity and the vertebral column, and thickens anteriorly to form a large lobe over the stomach. Pouch of gut from which the pyloric caeca open with two large nematode parasites.

The accompanying female (No. 6058b) possesses 11 pyloric caeca. Seven parasitic worms coiled partly in caeca, in pouch and also in upper intestine.

Development: Of the total catch of this species, 3,645 are young, showing no signs of luminous glands, and measuring from 6 to 27.5 mm. in length; 42 males measure 29 to 66 mm.; and 21 females measure from 34.5 to 67.5 mm.

Vertical distribution: Of the 3,708 specimens, the vertical distribution is as follows:

DEPTH FATHOMS	NO. OF FISH
0	3,286
200	406
400	8
500	6
800	2

The surface fish were all taken after dark, with the exception of 21 individuals, comprising one-half of one per cent., all young, which were captured at the surface in daylight.

This would indicate that *Myctophum affine* is essentially a nocturnal surface swimmer (88 per cent. of the entire collection being captured at this level), descending to extremely dark depths (200 fathoms maximum) during the hours of daylight. As the nets were non-closing it seems likely that the 16 fish taken at 400, 500 and 800 fathoms, may actually have entered the nets on their way to the surface.

Sociability: Seasonally, at least, it would seem certain that *Myctophum affine* lives in large schools. As will be seen from the accompanying table, nine nets contained from 100 to 1,100 fish each. These totalled 3,213, or 86 per cent. of all this species collected. Especially significant is the fact that eight

of these nine hauls were made between April 14 and 29. All the fish in these captured schools were young, except for 16 adults taken in the single non-April haul of June 13. Also all except one net was a surface haul, and that contained 406 fish from 200 fathoms.

Date	No. of Fish	Depth Fathoms	Cat. No.
April 12	124 Young	0	5281
April 14	280 Young	0	5234
April 15	266 Young	0	5332
April 20	1,100 Young	0	5373
April 21	406 Young	200	5507
April 22	456 Young	0	5387
April 23	111 Young	0	5424
April 29	306 Young	0	5507
June 13	164 (148 Young)	0	6399
	(14 Males)		
	(2 Females)		

Aside from the above nets, 52 others averaged only eight fish to a haul, and in 17 there was only a single fish each.

Food: The stomachs of 10 specimens contained only copepods, with a few small amphipods and fish eggs.

Luminescence and viability: Three notes on the lights of this species will show the more usual reactions after capture. A 19 mm. individual was taken at Station 30 T-1, Cat. No. 5133. In an aquarium it survived for ten minutes. For a considerable time it showed no light and then the entire fish was outlined by almost every one of the 80-odd organs. Then it would become completely dark and light up again, this occurring about every 15 seconds. Rarely several spark-like rays shone forth, penetrating, clear and brilliant. I happened to lift my wrist watch with its dully luminous dial close to the fish and it reacted at once, giving out two strong discharges of the caudal glands. Concealing the watch and later displaying the light of its face resulted in instant reaction. This happened eight times. I then flashed on my much stronger flash-light with no result. For five minutes I alternated the two artificial sources of illumination with identical results, the fish reacting vigorously to the watch dial, but paying no attention to the electric torch.

From the haul Station 63 T-1 a 20 mm. myctophid was taken to the dark room, but although apparently dead, throughout ten minutes it showed only one source of light, that from the pair of terminal, sub-mandibular, branchial organs. Twenty other fish were lively. At first the presence of numerous *Noctiluca* and *Sapphirina* made accurate observation difficult, but when clear water was substituted, two general types of illumination were distinguishable, an indirect glowing, constant but impossible to restrict to any organ or group of organs. The entire fish glowed with a generalized light, the scale mirrors gleaming in a marvelous manner, which gave the appearance of coming from some outside source in the room, were it not that I was sitting in absolute darkness. The other lights were sudden, abrupt, short, sharp, distinct flashes as from a make-and-break apparatus. After an hour of watching, when rigor mortis seemed to have set in, and all movement had ceased, a short renewal of the lights could be brought about by shaking the water or pinching the fish.

Net T-2 of Station 88 on the *Arcturus* was a surface haul made at 9 P. M. on June 13, 1925, three miles north of the island of Albemarle, Galápagos. A number of full grown *Myctophum affine* were taken at once down to the dark room where they darted about a small aquarium. A slight tap on the glass was sufficient to increase the constant luminescence of the lateral photophores, but this light was at all times so steady that it was easy to distinguish every organ and hence to make certain of the species. The lumination was light yellowish-green, as near as I can give it a name. As the fish grew weaker this light did not die out but became dull and indistinct.

The ventral batteries were stimulated irregularly and unexpectedly. It was difficult to say whether a tap on the glass, or collision with another fish, or some unidentifiable emotion was the cause, or perhaps all three at various times. As with other species of this genus, I never saw the secondary sexual caudal lights function when the fish was alone; only when several were together and in a state of excitement or fear, as on the first introduction to an aquarium, or at a sudden disturbance due to the adding of more water or fish. Under normal conditions of environment this light may well have a sexual function, as in attracting the opposite sex, but in the narrow, artificial confines of an aquarium, its principal effect on human spectators was a momentary blinding, with immediate visual disappearance of the fish. The power of this glandular light is very much greater than that given off by all the other organs together. The entire dark room was momentarily illumined when the supra- or infracaudal glands flared out. There seemed no difference in intensity between the light of the males or females.

In daylight the general appearance of the fish was deep purple, in sharp contrast to the brilliant silver scales of *Myctophum coccoi.*

Study Material.

A total of 3,706 specimens was taken, as follows: *Arcturus* Expedition, Station 30 T-1(1); 31 surface(1); 33 T-2(35); 38 T-1(6); 38 Pt-2(1); 39 T-1(1); 39 T-2(8); 39 T-3(124); 39 T-5(3); 41 T-1 (6); 41 T-3(279); 45 T-1(266); 47 T-1(1100); 49 T-1(406); 49 T-2(1); 50 T-2(1); 50

T-5(456); 52 T-1(38); 52 T-1(1); 52 T-1(2); 52 T-2(111); 52 T-3(3); 53 T-3(4); 57 T-1(306); 62 T-1(1); 63 T-1(1); 63 T-1(10); 65 Ot-1 and T-3 and T-4(2); 65 surface(8); 74 T-1(1); 74 T-23(17); 74 T-26(2); 74 T-29(2); 74 T-35 to T-40(4); 74 T-41(8); 74 T-43 and T-44(4); 74 T-61 to T-66(3); 84 T-2(1); 84 T-5 and T-6(5); 84 T-14(1); 84 T-16(1); 84 T-16(13); 84 T-15 to T-17(61); 85 T-1(30); 86 T-4(2); 86 T-7(1); 86 T-8(1); 87 T-2(4); 87 T-3(1); 87 T-6(1); 88 T-1 and T-2 to T-4(164); 88 T-1(3); 88 T-2(2); 88 T-3(20); 88T-4(5); 90 T-1 and T-2(18); 91 T-1(28); 91 T-1 and T-2(12); 91 T-2(29). Templeton Crocker Expedition, Station 170 L-1(1). Eastern Pacific (*Zaca*) Expedition, Station 177 L-1(2); 225 T-1(1); 227 T-1(3); 228 T-1(1); 231 L-1(25). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 110).

Scopelus affinis:

Lütken, 1892, p. 252, fig. 10. (Brief description; key; ? to 37 specimens, including type; ? mm.; ? fathoms; mid-Atlantic, off south Africa, Indian Ocean).

M. (Myctophum) affine:

Brauer, 1906, p. 190, figs. 105-7. (*partim:* Synonymy and description; ? to 76 specimens; ?-78-? mm.; 380 to 1,914 fathoms; Gulf of Guinea, Cape Verde, Bay of Bengal, Indian Ocean, Seychelles Islands).

Zugmayer, 1911, p. 27. (1 specimen; 34 mm.; ? to 275 fathoms; Mediterranean).

Pappenheim, 1914, p. 193. (4 specimens; 15 to 19 mm.; ? fathoms; north Atlantic, near Cape Verde, mid-south Atlantic).

Bolin, 1939, pp. 92, 110, fig. 11. (Key and description; 9 specimens; 28.7 to 72 mm.; ? fathoms; open Pacific, off Guadalupe Island, Atlantic Ocean).

Myctophum opalinum:

Goode & Bean, 1895, pp. 72, 511, fig. 81. (61+ specimens, including types; ? mm.; 104 to 1,536 fathoms; northwest Atlantic).

Jordan & Evermann, 1896, p. 571. (Brief description).

Waite, 1904, pp. 153, 193. (1 specimen; 95 mm.; ? fathoms; Lord Howe Island, near Australia).

Breder, 1927, p. 17. (? specimens; 25 to 50 mm.; ? fathoms; West Indies).

Myctophum nitidulum:

Garman, 1899, p. 266, pl. LVI, fig. 3. (Type description; ? specimens; ? mm.; ? fathoms; northwest of Hawaiian Islands).

Rhinoscopelus oceanicus:

Jordan & Evermann, 1903, p. 68, fig. 15. (General description; 2 specimens; type and co-type; 25 mm.; surface; near Hawaii).

Myctophum margaritatum:

Gilbert, 1905, p. 596. (General description; ? specimens, including type of 80 mm.; surface; near Hawaii).

Myctophum affine:

Goode & Bean, 1895, p. 72. (Brief description).

Jordan & Evermann, 1896, p. 570. (Brief description; key).

Lönnberg, 1905a, p. 63. (1 specimen; ? mm.; surface; South Atlantic, off Brazil).

Gilbert, 1908, p. 217. (Brief discussion of range and anal photophores; ? specimens; ? mm.; ? fathoms; mid-Pacific, south to Marquesas).

Gilbert, 1911, p. 14. (Name listed; 1 specimen; ? mm.; ? fathoms; west of Galápagos).

Gilbert, 1913, pp. 75, 76. (Key and discussion of anal photophores; 17 young specimens; ? fathoms; Japan).

Gilbert, 1915, p. 312. (Synonymy and distribution; 1 young specimen; surface; Catalina Island, off coast California).

Weber, 1913, p. 87. (Synonymy and distribution; 2 specimens; 14 mm.; ? to 821 fathoms; Banda Sea).

Weber & Beaufort, 1913, p. 161. (Synonymy and description).

Jordan & Jordan, 1922, p. 11. (Name listed).

Parr, 1928, pp. 65, 69-74, figs. 8, 9. (Key; synonymy; general and detailed description, including study of light and dark pigmentation; 32 specimens; ? mm.; surface; Bahamas).

Parr, 1934, p. 45. (Synonymy).

Tåning, 1928, p. 53. (Key to species).

Fowler, 1928, p. 69, fig. 13. (Synonymy and description).

Norman, 1929, p. 514. (Brief reference).

Norman, 1930, p. 325. (8 specimens; 12 to 30 mm.; surface to 300 fathoms; south Atlantic).

Beebe, 1929, p. 15. (Preliminary listing; 4 specimens; ? mm.; surface to 800 fathoms; Hudson Gorge, North Atlantic).

Beebe, 1937, p. 204. (Preliminary listing; 37 specimens; 13 to 25 mm.; 400 to 1,000 fathoms; Bermuda).

LeGendre, 1934, p. 336. (Key to species).

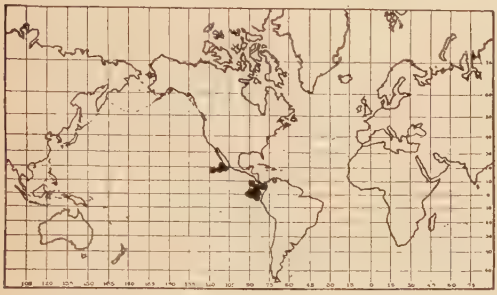
Myctophum aurolaternatum Garman, 1899.

Specimens taken by Eastern Pacific Expeditions: 113 specimens; *Arcturus* Oceanographic Expedition; surface to 800 fathoms; between 2° S. and 6° 40′ N. Lat., and 80° 48′ and 91° 53′ W. Long.; lengths 18 to 82.5 mm.; between April 12 and June 19, 1925.

3 specimens; Templeton Crocker Expedition; at the surface; between 18° 44′ and 22° 30′ N. Lat., and 110° 15′ and 114° 20′ W. Long.; lengths 31 to 80 mm.; between May 7 and 9, 1936.

9 specimens; Eastern Pacific (*Zaca*) Expedition; surface to 500 fathoms; between 4° 30′ and 9° 15′ N. Lat. and 78° 33′ and 85° 10′ W. Long.; lengths 21 to 37 mm.; between Feb. 7 and March 26, 1938.

Specimens previously recorded: 31 specimens; ? to 90 mm.; surface; mouth of the Gulf of California and off Panama. Our specimens extend the range south to Cocos Island and the Galápagos.



TEXT-FIG. 3. Distribution of *Myctophum aurolaternatum.*

Photophore count and variation: Out of the total of 125 fish taken, 115 were available for photophore counts, the remaining 10, from 18 to 23 mm., being too young to show any trace of these light organs. In the 115 fish there were 21 different combinations of the anterior and posterior AO photophores, 11 of which were asymmetrical, showing different combinations on the two sides. With 10 symmetrical variations, the balance between the two was much more even than in *Myctophum affine.*

There were two very evident numerical nodes, 10-6, 10-6; and 11-6, 11-6, with 16 fish showing the first, and 29 the latter arrangement. Fifty per cent. of the fish presented one or the other of these two combinations. The extremes in actual number of photophores were 9-6, 9-6 totalling 30, and 12-6, 12-6 with a total of 36. Far from showing any correlation with age, the smallest (18 and 20 mm.) and the largest (82.5 mm.) shared the largest number of photophores.

Luminous glands: Out of a total of 125 fish, only 11 showed evidences of the supra- and infracaudal luminous glands, of which six were males and five females. Unlike the condition in *Myctophum affine* there was no correlation of size with number of glands, the males showing 45 mm. (5 glands), 60 mm. (7), 66 mm. (6), 70 mm. (9), 75 mm. (8), and 80 mm. (7 glands). In a 68 mm. female the glands were barely discernable, while a 70 mm. male and female each had 9 well developed. Bolin records a fish of 60.5 mm. showing no trace of the glands.

Sex proportions: As already stated, of the 11 specimens with sexually distinct luminous glands, six were males and five were females.

Breeding: Three dissected fish showed the following conditions: Female No. 5539, 68 mm. in length, taken April 23 off the Galápagos, had the infracaudal glands barely discernable, and the ovaries with no enlarged eggs, showing no signs of imminent breeding.

Female No. 25580, 80 mm. long, captured on May 8, 180 miles southwest of the tip of Lower California, had four small caudal plates, and the ovaries quiescent, with no enlarged eggs.

Female No. 6059, 76 mm. long, taken June 1, 60 miles south of Cocos Island, showed three well developed infracaudal glands. The ovaries were in breeding condition, with approximately 1,200 eggs in each ovary, large and about to be laid. Scattered among them were many very small eggs.

Development: Out of 125 fish taken, 114 were glandless young, measuring from 18 to 41 mm. Eleven showed the glands of sexual differentiation, 45 to 82.5 mm. lengths, although these are not necessarily to be classed as full-grown adults (see under *Breeding*).

Vertical distribution: All 125 specimens of *Myctophum aurolaternatum* were taken at the surface after dark, or at depths which negatived surface conditions of sunlight. In all, 109 (including the 11 large, sexually distinct individuals) or nearly 88 per cent. of the total catch, were taken at the surface, mostly in the evening from 6 to 10 P. M., but a few as late as 4 A. M.

The remaining 16 fish were distributed so evenly between 200 and 800 fathoms that they may be accredited to casual captures, perhaps entering the nets at higher elevations than the extreme depths of the hauls indicate. The actual data are; 200 fathoms (1 fish), 300 (1), 400 (2), 500 (6), 600 (3), 700 (2), and 800 fathoms (1 fish). The fact that none were taken in daylight surface hauls suggests that there is a decided migration downward during daylight hours.

Sociability: Very convincing evidence is shown of schooling, since 66 specimens, representing 53 per cent. of the total 125, were taken in four nets. The details are as follows: 25 nets (1 fish each), 9 (2), 2 (3), 2 (4), 1 (6), 2 (8), 1 (16), and in 1 net (30 fish).

Food: Representatives of three Phyla were found in the stomachs of *Myctophum aurolaternatum:* Coelenterata, Crustacea and Mollusca.

The contents of 10 stomachs are typical of the food in general. All these fish were taken at the surface at night: Cat. No 5324

(36 mm.) 1 hyperian amphipod, 1 pycnogonid; 5539 (68 mm.) 3 amphipods; 6057 (41 mm.) 1 caridean; 6057 (37 mm.) 1 stalk-eyed shrimp, 3 amphipods, 3 copepods; 6059 (76 mm.) 4 copepods; 6061 (71 mm.) 4 isopods; 6061 (41 mm.) 1 isopod, 2 copepods; 6270 (38 mm.) 1 small squid, red eye with accessory light organs, 2 copepods; 6270 (36 mm.) 1 small squid, red eye, no light organs, 3 copepods; 6421 (75 mm.) 2 euphausids, 2 siphonophore segments, 3 zoea.

Luminescence and viability: Even in the specimens taken at the surface, viability was so poor that only three fish survived transportation to the dark room from the lighted deck. In all of these the lateral AO photophores were glowing with a faint bluish radiance. From one fish, three short, very intense, pale flashes were recorded, so powerful that the entire fish, its jar and our hands were brilliantly illumined.

Parasites: Four of the larger specimens, with well-developed glands, had large parasitic copepods attached to the sides, all with a pair of dangling ovaries.

Study Material.

A total of 125 specimens was taken, as follows: *Arcturus* Expedition, Station 39 T-3(1); 41 T-3(1); 45 T-5(3); 47 T-1(2); 49 T-1(1); 50 T-1(1); 52 T-1(1); 52 T-2(2); 57 T-1(2); 58 T-1(1); 59 T-8(1); 59 T-9(1); 61 Pt-1(1); 61 T-4(1); 61 T-5(1); 62 T-1(2); 65 T-4(3); 65 Ot-1 to Ot-4(8); 73 T-1(2); 74 T-26(1); 74 T-35 to T-40(16); 74 T-40(1); 74 T-41(2); 74 T-42(30); 74 T-41 and T-42(6); 74 T-43 and T-44(8); 74 T-69 to T-71(2); 74 T-70(1); 84 T-15 to T-17(4); 84 T-21(1); 86 T-4(1); 87 Pt-1(2); 88 T-2(1); 90 T-1 and T-2(1); 91 T-2(1). Templeton Crocker Expedition, Station 160 L-1(1); 161 L-1(1); 162 L-1(1). Eastern Pacific (*Zaca*) Expedition, Station 210 T-3(1); 210 L-1(2); 210 T-8(1); 228 T-1(1); 231 L-1(4). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 108).

Myctophum aurolaternatum:

Garman, 1899, p. 264, pl. IV, fig. 3. (4 large and 21 small specimens, including type; ? to 90 mm.; surface; Gulf of Panama. Description and reference to luminosity).

Parr, 1928, p. 65. (Key to species).

Parr, 1934, p. 43, fig. 2. (Examination and redescription of type specimens).

Myctophum (Myctophum) aurolaternatum:

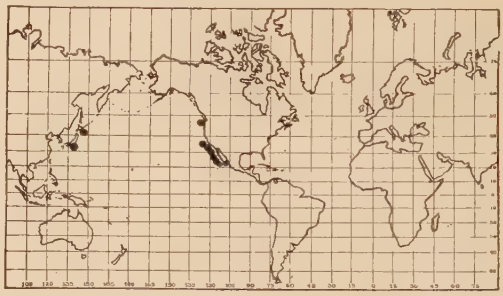
Bolin, 1939, pp. 92, 105, 108-109, fig. 10. (6 specimens; 31 to 72.4 mm.; ? fathoms; Gulf of California and off Panama).

Myctophum californiense *Eigenmann & Eigenmann*, 1889.

Specimens taken by Eastern Pacific Expeditions: 5 specimens; Templeton Crocker Expedition; surface to 500 fathoms; between 23° 25′ and 30° N. Lat., and 108° 31′ and 116° 27′ W. Long.; lengths 31 to 38 mm.; between April 29 and May 23, 1936.

8 specimens; Eastern Pacific (*Zaca*) Expedition; surface; 31° 25′ N. Lat., and 116° 58′ W. Long.; lengths 30 to 44 mm.; taken on Nov. 7, 1937.

Specimens previously recorded: 13 specimens; ? to 121 mm.; ? to 534 fathoms; both shores of the Pacific, on the east from Puget Sound to Cape Lucas, and in the west, off Japan. Material in the present paper extends the known range about 600 miles south, 48 miles east of Arena Point, Lower California.



Text-fig. 4. Distribution of *Myctophum californiense*.

Photophore variation: There is little variation in the number of anal photophores in our 13 specimens. The commonest pattern is a symmetrical 7-9, shown by 8 specimens, or more than 60 per cent. of the fish. Eleven out of the 13 possess symmetrical patterns.

Other data: The 13 fish were all young, showing no trace of luminous glands. The extremes of measurements were 30 and 44 mm. One fish of 42 mm. taken at night at the surface had eaten 2 copepods and 1 mysid. Of the 13 specimens, 11 were taken with dipnets as they came to our night lights, three on May 23, 1926, and eight on November 7, 1937. The remaining two, although taken in a 500-fathom net, were probably much nearer the surface when they entered. Bolin says, "In life the luminous organs emit a pale greenish light."

Study Material.

A total of 13 specimens was taken, as follows: Templeton Crocker Expedition, Station 158 T-4(2); 174 L-1(3). Eastern Pacific (*Zaca*) Expedition, Station 176 L-1(8). For detailed trawling data, refer to *Zoologica*, Vol XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 106).

Myctophum californiense:

Eigenmann & Eigenmann, 1889, p. 124. (Type specimen; ? mm.; 45 fathoms; Cortez Banks).

Jordan & Evermann, 1896, p. 572. (Key and description).

Gilbert, 1913, p. 78. (3 specimens; all 127 mm.; ? fathoms; off Santa Barbara Islands).

Townsend & Nichols, 1925, p. 10. (1 specimen; ? mm.; 534 fathoms; southwest of Santa Barbara Islands).

Parr, 1928, p. 64. (Key and synonymy).

Parr, 1929, p. 10, fig. 4. (Further description of type).

Bolin, 1939, pp. 92, 106, fig. 9. (8 specimens; 24 to 103.3 mm.; ? fathoms; eastern Pacific off Central California, south to Mexico; key to species and description).

Scopelus californiense:

Lütken, 1892, p. 267. (Reference).

Myctophum (Myctophum) humboldti:

Brauer, 1906, p. 192. (Part of this description confused with *Myctophum californiense*).

Myctophum coccoi (*Cocco*, 1829).

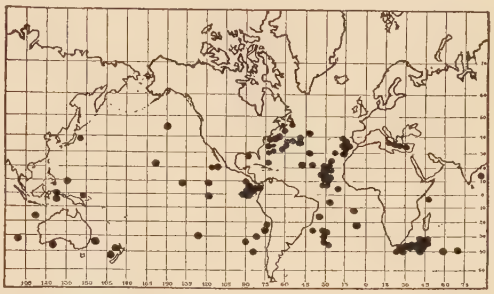
Specimens taken by Eastern Pacific Expeditions: 4,460 specimens; *Arcturus* Oceanographic Expedition; surface to 1,000 fathoms; between 6° 58′ N. Lat., and 2° 00′ S. Lat.; and between 80° 48′ and 91° 47′ W. Long.; lengths 13 to 51 mm.; between April 3 and June 19, 1925.

3 specimens; Templeton Crocker Expedition; surface; at 18° 44′ N. Lat., and 114° 20′ W. Long.; and at 21° 20′ N. Lat., and 115° 14′ W. Long.; lengths 20 to 29 mm.; May 9 and 17, 1936.

3 specimens; Eastern Pacific (*Zaca*) Expedition; surface; 4° 30′ N. Lat., and 78° 33′ W. Long.; lengths 13 to 20 mm.; March 26, 1938.

Specimens previously recorded: 996+ specimens; ? to 110 mm.; ? to 2,620 fathoms; in all parts of the Atlantic Ocean, north, south, east and west, as well as mid-ocean, between 40° S. Lat. and 48° N. Lat.; Mediterranean Sea, Cape of Good Hope, south of Zanzibar, Bay of Bengal, Indian Ocean, east and west of Australia, Admiralty Islands, Philippines, Japan, mid-Pacific, south-east of Hawaii, between Galápagos and Marquesas Islands, Gulf of Panama, coast of Central America, off coast of Chile.

In the eastern Pacific *Myctophum coccoi* is very evidently more at home in southerly warm waters, as witness the 4,400 specimens taken on the *Arcturus*, between Panama and the Galápagos, this number being almost half the total of all the members of this family taken on the whole of this expedition. On the other two expeditions only 6 were taken, all at the surface at night lights. One swam into a dipnet about 50 miles north of Gorgona off the Columbia coast, and a single specimen came from well off shore at a latitude only 100 miles south of Cape Lucas, forming the northernmost Pacific record for this species. Thus 20 degrees north is the limit in the Pacific, whereas in the Atlantic, *coccoi* is found as far north as 48 degrees. Forty degrees south seems the abrupt deadline for the species all around the world. Within these latitudinal limits the fish may be said to be almost cosmopolitan.



Text-fig. 5. Distribution of *Myctophum coccoi.*

Photophore count and variation: There is a great variation in the number of anal photophores, even in the same specimen, fish after fish having a different count on either side. This has nothing to do with sex or age. A count of the anal photophores on more than 200 specimens, reveals that the most common combination (76 specimens) is 6-11. The next most common is 6-10. To summarize, there are six combinations in 136 fish, 35 combinations in 73 fish, or a total of 41 separate combinations in 209 fish.

Previous studies on about 1,500 freshly caught fish resulted into their division into dominant variants from the standard numbers of anal photophores, there being eight distinct types in addition to the more normal ones.

Types of variations other than Numerical, in Anal Photophore Groupings.

1. No break between anterior and posterior groups, one side only.
2. No break between the posterior group and the precaudal photophores.
3. Anterior group divided between second and third photophores.
4. Anterior group irregular in spacing because of the apparent insertion of an extra photophore.
5. One photophore in series out of line with the rest.
6. Break in either group or in the precaudals.

7. Three precaudals instead of two, on one or on both sides.

8. Smaller photophores in the series.

The extent of the eight variants in 1,104 individuals is unexpectedly great. Including males, females and older young, 57.8 per cent. possess the normal complement and arrangement of anal photophores, while those fish showing one, two or three of the variations comprise the remaining 42.2 per cent.

Luminous glands: As in nearly related species, the presence of supracaudal glands indicate male fish more or less adult, while the female is associated with infracaudal glands. Ontological development is shown by the following 70 fish, 37 of which were males, and 33 females.

Males of 34 to 40 mm. average 4.4 glands; those of 40 to 45 mm. 4.4 glands; males 45 to 50 mm. 5.2 glands. Females of 34 to 40 mm. possess an average number of 3 glands; those 40 to 45 mm. 3.5 glands; those of 45 to 50 show 4 glands. This indicates a slow but certain increase in number of glands with increase in standard length.

Sex proportions: Eleven hundred and four *M. coccoi* were taken at two *Arcturus* stations in the Pacific, Station 39, T-1; and 84, T-15 T-16 and T-17). This number comprised 24.7 per cent. of the entire Pacific catch of this species. Of these 1,104 fish, 619 were young, 253 males and 232 females. In a few other small catches the females actually equalled the numbers of the males, so that occasionally the balance is quite even between the sexes. The total count of all 4,466 Pacific *M. coccoi* resolves into 45.7 per cent. young, 30.6 per cent. males, and 23.7 per cent. females.

Breeding: A full grown female of 50 mm. length, taken at the surface off the Galápagos on April 12, had ovaries 9 mm. in length. The egg diameters were .25 mm. and the total count of the eggs in one ovary was 1,648, or about 3,300 eggs altogether.

Vertical distribution and migration: The number of *M. coccoi* taken below the surface is negligible, except in the case of a single net drawn at a depth of 200 fathoms, in the evening, from 7.40 to 8.35 P. M. and which contained 42 fish. Deeper hauls averaged 300 fathoms (4 fish), 400 (2 fish), 500 to 1,000 fathoms (1 fish each). The total of sub-surface fish is 59 as compared with 4,407 from the surface. Doubtless the great majority, if not all, of the 17 individuals from below 200 fathoms were adventitious, probably entering at or near the surface during the brief passage of the net at the upper levels.

The daily migration is evident from the following table, giving the number of fish drawn at successive half hours. A. M. hauls were actually consecutive.

Hour		No. of Fish
A. M.	12.00-12.30	39
	1.00- 1.30	26
	2.00- 2.30	25
	3.00- 3.30	10
	4.00- 4.30	10
	4.30- 5.00	13
	6.00- 6.30	2
(No fish taken between 6.30 A.M. and 6.30 P.M.).		
P. M.	6.30- 7.00	5
	7.00- 7.30	63
	7.30- 8.00	113
	8.00- 8.30	186
	9.00- 9.30	145
	9.30-10.00	88

This sequence was confirmed by several Station series well removed from one another. At Station 74 I made half-hour hauls around the clock, and again fifteen-minute hauls at 5 to 7 o'clock both morning and evening, to confirm the regularity of appearance and disappearance. This slender-tailed lantern fish comes up from rather shallow depths just after dark on the equator and rapidly reaches its greatest abundance, or perhaps at this time, 8-9.30 P. M., keeps in very dense, compact schools. Throughout the night its numbers in the nets decrease, probably from a general scattering in search of food, and the last individual dives into darker levels at 6.30 A. M. at the very latest. Judging from the contents of our nets, the younger fish appear at the surface first, and seem to vanish sooner than the older ones, but this last statement is less certain because of the suddenness with which all descend.

Rough water seems to deter them but little in their vertical movements, but a much more potent factor is the presence or absence of moonlight. On a cloudy night a half hour tow brought in 40 fish, while on the following night, in clear, nearly full moonlight, a similar net at a corresponding hour captured only two. Fifteen additional instances all provided identical data.

Only rarely have I observed this lantern fish in its native element. At the foot of the companionway with an electric light cluster swung low over the water, on three occasions I have observed this species, and twice captured it. I can account for this unexpected positive phototropism only by a reversal of reaction due to some factor in the greater intensity and concentration of the illumination.

As my nightly tows show, *coccoi* is present in large numbers at the surface of a wide area of the Pacific. Whenever many individuals have been taken in one net, the variation in age has been great, very young and fully developed adults being mingled together. In general shape and in the remarkably nondeciduous scales *coccoi* differs greatly from its generic relations.

Sociability: While the summation of catches presents a uniform and logical picture of vertical distribution, migration and sociability, irregularities are now and then apparent. For example, two nets at Station 39, T-1 and T-2 drawn simultaneously, parallel, but from different sides of the stern, in a half hour's time caught respectively 4 and 72 fish, illustrating the concentration of schooling in certain places and at definite times. A third net attached ten minutes after the other two, captured 600 *M. coccoi* in thirty minutes.

The record for numbers in a short period of time was at Station 88, on the equator in the Galápagos, when four small nets, one-half metres, were pulled from 8.10 to 9.00 P. M.; 9.00 to 9.30; 9.35 to 9.40 and 9.45 to 9.50. The count of *M. coccoi* was 293, 315, 116 and 549. The last two hauls of five minutes each thus captured more than 66 fish a minute, and this in nets only 18 inches in diameter. The 1,273 *coccoi* here taken in a little more than an hour and a half, represent almost one-third of the entire catch on the *Arcturus* in the Pacific.

If we assume that 40 or more *coccoi* taken in a single net constitute evidence of schooling, then we find that out of 52 nets pulled on the surface, 25 come within our assumption. These include captures of 40 to 600 individuals, in all 4,147 fish, or about 92 per cent. of the entire catch, an average of 165 *coccoi* to each net.

Food: The slender-tailed lanternfish is altogether a plankton feeder. In the beginning of our deep sea work, my assistants several times brought me individual fish which had partly ingested the entire head of a fellow *M. coccoi*. This astonishing sight was subsequently observed a number of times, and proved to be wholly accidental. The newly caught fish, gasping and gaping widely, wriggling about at full speed in a small aquarium, sooner or later ran against and partly engulfed the head of a smaller fish.

A haul at the surface on June fifth, near the Galápagos, at Station 78, T-1, yielded 40 *Myctophum coccoi*. These were all examined at once for the contents of their stomachs with the following results:

1. 3 small calanids, 5 hyperids, 3 *Corycaeus*, 1 euphausid.
2. 12 calanids, 3 hyperids, 1 *Halobatis*, 1 small *Atlanta*.
3. 1 calanid, 5 hyperids, 1 *Atlanta*, 1 *Pontella*.
4. 21 calanids, 1 *Candace*, 1 *Monops*, 1 *Pontella*, 1 *Sapphirina*, 3 hyperids, 1 euphausid, 1 *Atlanta*, 1 *Limacina*.
5. 15 calanids, 1 *Corycaeus*, 5 hyperids, 1 *Monops*, 1 *Limacina*.
6. 18 calanids, 3 hyperids, 1 mysid, 1 fish egg, 1 *Globigerina*.
7. 22 calanids, 4 hyperids, 3 *Atlanta*, 3 *Globigerina*, 1 *Limacina*.
8. 2 *Monops*, 1 schizopod, 1 fish egg, 13 calanids, 1 *Sagitta*.
9. 9 hyperids, 21 calanids, 25 *Limacina*, 1 *Atlanta*, 1 *Monops*.
10. 8 calanids, 3 hyperids.
11. 9 calanids, 6 hyperids, 2 *Limacina*, 3 *Sagitta*, 3 *Globigerina*.
12. 14 calanids, 4 hyperids, 2 *Sagitta*.
13. 7 calanids.
14. 8 calanids, other material.
15. 2 hyperids, 5 *Sagitta*, 2 *Corycaeus*.
16. 1 hyperid.
17. 3 *Sagitta*, 4 calanids, 1 hyperid, 5 fish eggs.
18. 1 hyperid, 1 euphausid, 8 calanids, 4 *Limacina*, 1 ostracod.
19. 7 hyperids, 1 *Monops*, 2 fish eggs, 1 *Globigerina*.
20. 8 hyperids, 1 *Ianthina*, 2 fish eggs, 1 *Limacina*.
21. 2 hyperids, 1 euphausid, 3 calanids.
22. 2 *Candace*, 3 fish eggs, 6 hyperids.
23. 3 small mollusks, 2 hyperids, 2 small worms.
24. 14 *Candace*, 2 hyperids.

25 to 40. Fifteen stomachs empty or with unrecognizable material.

The general aspect of this food of *M. coccoi* resolves into the following:

	No. Times Eaten	No. Individuals
Annelids	2	2
Atlanta	5	7
Calanids	17	183
Corycaeus	2	5
Euphausids	4	4
Fish eggs	7	15
Gastropods	1	3
Globigerina	5	9
Halobatis	1	1
Hyperids	21	80
Ianthina	1	1
Limacina	6	34
Monops	4	5
Mysids	2	2
Ostracods	1	1
Pontella	3	3
Sagitta	5	14
Sapphirina	1	1
Schizopods	1	1
	89	371

Carrying this finally to groups, we find that fish eggs have entered 7 times into the diet; insects once; mollusks 13 times, crustaceans 55 times; annelids 77 times and protozoans 5 times.

Viability: Roughness of water seems to make very little difference to this fish, and on nights when the sea was rough and the

swell heavy, I have still taken them in abundance. At such times other species of myctophids have remained below, perhaps in part due to the delicacy of attachment of their scales. *Coccoi* can stand an astonishing amount of buffeting and handling without the loss of a single scale.

Viability is another quality which sets *coccoi* apart. A net full of mixed surface fish will always have living *coccoi* after all the others have died. Not only this, but there is marked individuality within the species. One fish which we named "Methuselah" lived on and on after I had subjected him to all sorts of experiments, dropped him on the floor twice, and placed him for a moment by mistake in a bowl of formalin.

The moment a slender-tailed lanternfish is removed from the tow net and placed in a container of clear salt water, he begins swimming violently and ceases activity only with death. Other myctophids sometimes rest or relax somewhat their violent efforts at escape, but *coccoi* never. The contour of the body, slender and compressed anteriorly and drawn out into an elongated narrow posterior, compels a wholly different method of progression from that of its stouter, more rounded relatives. There is no steady or slightly undulatory movement, but a violent wagging of the entire body and tail, such as is seen in small elvers and muraenoids. In a still living lanternfish the tail can be bent around more than 360 degrees from the anterior portion of the body and tail, forming more than a complete circle. Much of this entire flexibility is apparently utilized at each progressive effort.

As in the case of many other deep-sea fish, the first instinct on being exposed to light, is to descend. This is the case both in shallow dishes and in deep aquaria. The fish makes one straight dive to the bottom, and from then on gyrates head downward, twisting and pushing, endeavoring to achieve the only known method of escape. From this and other facts, it seems certain that danger threatens these small beings almost altogether from above. Once when a short haul had provided some unusually virile, active lanternfish, by placing several immediately in an aquarium of running water, I managed to have one remain at the surface. It swam obliquely with the head at the very surface, and around and around rapidly, wriggling violently and covering every inch of the water. Furthermore, when the lights were turned out in the aquarium room, a large individual which had been bumping its head off against the bottom, suddenly veered upward, and wiggled to the surface, to dash about for a minute like its fellows. A sudden glare of light sent them both down to a few minutes more of gyration and then death.

Unexpectedly and with no cessation of the frantic wriggling movements I have seen fish at several different times, turn, seize and swallow small forms of plankton life which swam close to them, this in diffused room light plus the ventral sheet of luminescence.

Luminescence: The abundance and the unusual viability of *Myctophum coccoi* made possible the observation of these fish in the dark room of the *Arcturus*. Imagine a minnow which is iridescent copper above and silvery white below, not over two inches in length, with large eyes and moderate fins. A full-grown fish weighs a gram, which means that it would take about 450 to make a pound. It feeds on copepods, amphipods, floating snails and other minute plankton fry, and from this food it generates sufficient energy to swim, to make daily migrations up and down, to illumine one hundred lights and to deposit upwards of two to three thousand eggs.

Scattered over the body are many, small, round luminous organs, which we may divide into three general sets. First, 32 ventral lights on each side of the body, extending from the tip of the lower jaw to the base of the tail; second, about 12 lateral lights arranged irregularly along the head and body, and third, a series of three to six median light plates or scales, either above or below the base of the tail.

The lower battery, when going full blast, casts a solid sheet of light downward, so strong that the individual organs could not be detected. Five separate times when I got fish in a large, darkened aquarium, I saw good-sized copepods and other organisms come close, within range of the ventral light, then turn and swim still closer to the fish, whereupon the myctophid twisted around and seized several of the small beings. Once it turned completely on its back. I could never have seen this except that the glass sides reflected sufficient light. Whether this is the chief object of the ventral lighting I do not know, but it was at least effective on the several occasions when I was watching.

Perhaps the best distinction between various species of lanternfish is the arrangement of the lateral light organs, and in the darkroom in absolute darkness I could tell at a glance what and how many of each species were represented in a new catch, solely from their luminous hieroglyphics. When several fish were swimming about, these side port-holes were almost always alight, and it seems reasonable that they may serve as recognition signs, enabling members of a school to keep together, and to show stray individuals the way to safety.

The light scales of the tail are apparently of considerable importance. Ordinarily when the whole fish is glowing with the pale greenish light of luminescence, these caudal

lights are seldom seen. A clue to their use is found in the fact that they show a sexual difference, the males having them on the upper side of the peduncle and the females on the lower side. In my brief and sporadic observations, when no fish lived longer than thirty-six hours, there was no chance to watch signs of courtship or any such use which these lights might subserve. But when a fish exerted itself unduly to get out of the way of another, either of its own or another species, these lights would flash and die in quick succession. Three separate times in unusually strong, vigorous fish when the body luminescence was very dim, these scale searchlights flashed like heliographs, being much stronger than the combined, steadier glow of all the others. This luminescence was of a much deeper green than that of the ventral lights. If continuously alight, a single fish would have illumined the whole darkroom, and enabled one easily to read fine print.

In the dark it was thus possible to distinguish species of lanternfish by the lateral hieroglyphics and the sexes by the upward or downward direction of the tail lights. I have never seen the latter illumination given out by a fish swimming alone in an aquarium. Although it is very evident that the caudal flashes have some sexual significance, yet another very important function seems that of obliteration. It certainly was to my eyes and I have no reason to think that a natatory enemy might not also be frustrated. When the ventral lights die out they do so gradually, so that the eye holds the image of the fish for a time after their disappearance, but the eye is so blinded by the sudden flare of the tail lights that when they are as instantly quenched, there follow several seconds when our retina can make no use of the faint, diffused, remaining light, but becomes quite blinded. A better method of defense and escape would be difficult to imagine.

Specimens of *Myctophum coccoi* taken around midnight seemed to show less brilliant light and more intense color, a deeper turquoise green than those captured earlier. It seems possible that the color varies inversely in strength with increase of luminescence (at least in its effect on the human eye), that is, the more powerful the actual luminescence, the more it obscures the specific color. In lighted surroundings the luminous activity is minimized, and the color at maximum, while as the luminescence increases in intensity the color shows up less. To repeat, specimens taken under the above conditions show the color very well, whereas the luminescence was not as intense as that in fish caught at the surface soon after dark. This was observed independently by several of us again and again and seems to indicate a certain relative independence of light intensity and color functioning.

Enemies: While the number of the enemies of myctophids must be legion there is one which seems to consider these small fish as an almost exclusive item of diet. Not long after the first of the *coccoi* come to the surface, a somewhat larger, black fish is to be found in the same nets. In the glare of the laboratory lights this was not a very unusual appearing fish, although it had a short, dependent chin tentacle and a mouth with exceedingly wide gape. Its name is *Astronesthes*. Almost every specimen taken of this fish contained a recently swallowed *coccoi*, usually measuring about two-thirds the length of its enemy. In the dark, *Astronesthes* itself is a gorgeous sight, the skin covered with a host of minute luminous specks, while the fins fairly glowed with pale green light. Strangely enough, the stem only of the tentacle was luminescent, while the slightly enlarged tip was dark.

Parasites: Myctophum coccoi appears to be more susceptible to parasitic infection than is the case with other species of myctophids. For example, in a female 35 mm. in length, (Cat. No. 6397), three parasites were found in the body cavity; a larval cestode of the genus *Rhyncobothrium*, lying free in the left side between an ovary and the intestine. It measured 7 by 2.2 by .62 mm. and was transparent enough to show the proboscides. On the right side of the body cavity a 7 mm. larval acanthocephalid was situated slightly above and partly inside the pancreas. In front of the liver, between it and the pigmented peritoneal lining and just below the oesophagus, partly coiled around it, was an immature nematode, a 6 mm. *Anisakis*.

Study Material.

A total of 4,446 specimens was taken, as follows:

Arcturus Expedition, Station 33 T-1(1); 33 Pt1(1); 33 T-2(58); 38 Pt-2(2); 38 T-1 (8); 39 T-1(4); 39 T-2(71); 39 T-2(1); 39 T-3(70); 39 T-3 (529); 39 T-3(1); 39 T-5(87); 40 T-1(2); 41 T-1(2); 41 T-3 (135); 45 T-1(29); 45 T-1(1); 47 T-1(44); 47 T-1(27); 47 T-1(12); 47 T-1(2); 47 T-1(61); 49 T-1(42); 50 T-1(1); 50 T-5 (105); 52 T-1(6); 52 T-2(24); 53 T-3(2); 57 T-1(424); 58 T-1(5); 62 T-1(2); 63 T-1(3); 65 T-1(2); 65 T-3(2); 65 T-4(10); 65 surface(10); 67 T-1(2); 68 T-1(4); 68 T-5(1); 70 T-1(3); 73 T-1(5); 74 T-10(6); 74 T-11(20); 74 T-23(94); 74 T-26(39); 74 T-29(43); 74 T-35(2); 74 T-35 to T-40(78); 74 T-41(24); 74 T-43 and T-44(18); 74 T-46(13); 74 T-61 to T-66(50); 74 T-70(1); 77 T-1(17); 84 T-2(2); 84 T-5(41); 84 T-6(2); 84 T-8(3); 84 T-14(1); 84 T-15 to T-17(223); 84 T-16(282); 84 T-20(2); 85 T-1(103); 86 T-5(1); 86

T-8(1); 88 T-1 and T-2 to T-4(49); 88 T-1(274); 88 T-2(296); 88 T-3(116); 88 T-4(512); 90 T-1 and T-2 (163); 91 T-1 (174); 91 T-1(2); 91 T-2(16). Templeton Crocker Expedition, Station 162 L-1(2); 167 L-1(1). Eastern Pacific (*Zaca*) Expedition, Station 231 L-1(3). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-289 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Parr, 1928, p. 61).

Scopelus coccoi:

Cocco, 1829, p. 143. (Reference not seen).

Cocco, 1838, p. ?, pl. II, fig. 6. (Reference not seen).

Bonaparte, 1832-41, p. 138. (Description).

Cuvier & Valenciennes, 1828-49, vol. 22, p. 440. (Brief description; 1 specimen; no details).

Günther, 1864, vol. 5, p. 413. (Description; ? specimens; ? mm.; ? fathoms; Gulf of Guinea, Mediterranean and Atlantic).

Günther, 1889, vol. 31, p. 30. (Description; 80 specimens; ? mm.; ? fathoms; south of Cape Verde, near West Indies, south Atlantic, south Pacific, mid-Pacific, near Admiralty Islands and near Japan).

Canestrini, 1870, p. 125. (Reference not seen).

Doderlein, 1878-79, p. 54. (Name listed only).

Raffaele, 1889, p. 182, pl. 7, fig. 5. (Description).

Moreau, 1891, p. 90. (Description).

Collet, 1896, p. 116. (Description; synonymy; 42 specimens ? mm.; surface; Azores and south of Flores).

Gilchrist, 1908, p. 165. (150 specimens; ? mm.; surface; Cape Point, South Africa).

Thompson, 1916, p. 83. (Name listed, with synonymy).

Scopelus gracilis:

Lütken, 1892, p. 255, fig. 13. (Description; 5 specimens; ? to 50 mm.; ? fathoms; open Atlantic near Madeira, mid-north Atlantic, off Cape of Good Hope, south of Zanzibar, off coast of Brazil).

Scopelus jagorii:

Peters, 1859, p. 411. (Reference not seen).

Scopelus langerhansi:

Johnson, 1890, p. 454. (1 specimen; 110 mm.; ? fathoms; Madeira).

Lütken, 1892, p. 267. (Reference only).

Scopelus (Rhinoscopelus) coccoi:

Lütken, 1892a, p. 243. (? specimens; ? to 50 mm.; ? fathoms; large number of stations, both east and west, north and south Atlantic, east and west of Australia, south Africa, Zanzibar. All recorded on distribution map).

Carus, 1889-1893, p. 564. (Description).

Rhinoscopelus coccoi:

Goode & Bean, 1895, p. 90. (Brief description; ? specimens; ? mm.; surface to 2,620 fathoms; northwest Atlantic from Newfoundland to Gulf of Mexico, Bermuda, Madeira).

Jordan & Evermann, 1896, p. 568. (Description).

Fowler, 1928, p. 70, fig. 14. (References; synonymy; brief description).

Rhinoscopelus tenuiculus:

Gilbert, 1908, p. 222. (Brief description; 1 specimen; 50 mm.; ? fathoms; southeast of Hawaii).

Gilbert, 1911, p. 15. (Brief description; 12 specimens; 35 to 50 mm.; ? fathoms; midway between Galápagos and Marquesas Islands).

Jordan & Jordan, 1925, p. 11. (Name listed only).

Alysia loricata:

Lowe, 1839, p. 87. (Brief description).

Lowe, 1849, p. 14. (Brief description).

Myctophum coruscans:

Richardson, 1844-48, vol. 2, p. 40, pl. 27, figs. 1-5. (Description; 1 specimen; 57 mm.; ? fathoms; south Atlantic, Australia).

Scopelus coruscans:

Hutton, 1873, p. 270. (Brief description).

Myctophum hians:

Richardson, 1844-48, vol. 2, p. 41, pl. 27, figs. 19-21. (Description; 1 specimen; 50 mm.; ? fathoms; ? locality).

M. (Myctophum) hians:

Brauer, 1906, pp. 162, 194, fig. 12. (Key to species; description; synonymy; 1 specimen; 22 mm.; 1,903 fathoms; south Atlantic).

Barnard, 1925, p. 244. (Brief description).

Myctophum tenuiculum:

Garman, 1899, p. 262, pl. J, fig. 5. (Description; 1 specimen; 25 mm.; surface; Gulf of Panama).

Myctophum gracile:

Goode & Bean, 1895, p. 74. (Brief description).

Jordan & Evermann, 1896, p. 572. (Brief description).

Myctophum (Rhinoscopelus) coccoi:

Roule & Angel, 1933, p. 28. (1 specimen; 53 mm.; surface; Azores).

M. (Myctophum) coccoi:

Brauer, 1906, pp. 163, 199, figs. 116-120. (Key to species; description; synonymy; 380 specimens; ? to 52 mm.; between Azores and Newfoundland, north of Bermuda, West Indies, north of Bahamas, Gulf of Mexico,

south Atlantic, coast of Brazil, Madeira and Canary Islands, Cape Verde, Gulf of Guinea, Indian Ocean, Zanzibar, Admiralty Islands, East Indies).

Pappenheim, 1914, p. 194. (93 specimens; 20 to 46 mm.; ? to 1,642 fathoms; south Atlantic, Cape Verde).

Barnard 1925, p. 244. (Brief description).

Myctophum coccoi:

Weber & Beaufort, 1913, pp. 153, 158. (Key to species description; synonymy).

Regan, 1916, p. 134. (Description of larval and postlarval fishes of New Zealand and 3 Kings Island; 1 specimen; 20 mm.; 2 fathoms).

Sanzo, 1918a, p. 135. (Description of young).

Tåning, 1918, pp. 67-70, figs. 23, 24. (Detailed description of adult and postlarval fish; distribution map; 64 specimens; 5 to 34 mm.; surface to ? fathoms; eastern Mediterranean).

Tåning, 1928, p. 55. (Key to species).

Tåning, 1932, p. 113, figs. 1, 2. (Description of adults and postlarval; synonymy).

Barnard, 1925, p. 236. (Key to species).

Parr, 1928, p. 61. (Key to species and synonymy).

Parr, 1934, p. 45. (Brief discussion).

LeGendre, 1934, p. 337. (Key to species).

Beebe, 1937, p. 204. (Preliminary list; 165 specimens; 7 to 26 mm.; 300 to 1,000 fathoms; Bermuda).

Myctophum evermanni Gilbert, 1905.

Specimens taken by Eastern Pacific Expeditions: 105 specimens; *Arcturus* Oceanographic Expedition; surface to 1,000 fathoms; between 6° 40′ N. Lat., and 0° 03′ S. Lat., and 80° 49′ and 89° 50′ W. Long.; lengths 18 to 73 mm.; between Feb. 23 and July 29, 1925.

3 specimens; Eastern Pacific (*Zaca*) Expedition; 1 at 300 and 2 at 500 fathoms; between 9° 09′ and 8° 03′ N. Lat., and 83° 12′ and 85° 04′ W. Long.; lengths, 16, 16 and 18 mm.; Feb. 8 and March 10, 1938.

Of these myctophids 80 have been available for study.

Specimens previously recorded: 41 specimens; surface to 1,100 fathoms; Hawaii, Marquesas, East Indies and Japan. Our specimens are the first recorded from the eastern Pacific.

TEXT-FIG. 6. Distribution of *Myctophum evermanni.*

Photophore variation: Unlike other species of this genus the lateral photophores show no bilateral asymmetry. The pattern of 8-5, 8-5 is the most common, comprising 61 per cent. of the whole. The extremes are 7-5 and 8-6.

Luminous glands: Of 80 specimens, 44, from 16 to 31 mm. show no signs of caudal plates. Seventeen males, 40 to 69 mm. present 6 to 8 supracaudal plates. There is a decided increase in number with size, i.e., 6 fish with 6 plates average 48 mm.; 10 with 7 plates average 57 mm. and 1 fish with 8 plates is 56 mm. in length.

Nineteen are females and starting with a single plate faintly visible in a 43 mm. specimen, the series ends with four well-developed plates and a length of 73 mm. The corresponding series of lengths in the ascending plate scale is 45, 52, 53, 61, 61 and 67 mm.

Breeding: Specimen No. 6059, 68 mm. in length, taken June 1, is a female in full breeding condition with ovaries measuring 28 by 5.5 mm.

Vertical distribution: Eighty-five per cent. of the total catch was taken at the surface, all after dark. The 12 specimens brought up from open nets descending to 300 and 600 fathoms are so evenly distributed that they may well have entered at considerably more shallow depths. All 36 recognizable males and females were taken at the surface.

Sociability: Schooling, especially of older fish, is definitely shown from the fact that 43 of the 80 (including all the sexually recognizable specimens) comprising 54 per cent. of the whole, were taken in three hauls at the surface at night, while the remainder averaged one and one-half fish to the net. In one haul of 10 young fish, all were of exactly the same age, 22 mm. in length.

Food: In ten stomachs there were remains of three phyla; Crustacea, Mollusca and Pisces. The following groups were present in this order of abundance; copepods, 44 individuals of at least six species; 29 amphipods; 13 pteropods of three species; 13 euphausids; 4 schizopods; 3 larval fish; 2 shrimp.

STUDY MATERIAL.

A total of 84 specimens was taken, as follows: *Arcturus* Expedition, Station 29 surface(1); 31 surface(1); 47 T-1(10); 59 T-9(3); 65 T-3(1); 65 T-4(2); 65 T-4(1); 66 T-2(3); 66 T-2(1); 67 T-1(1); 68 T-5(1); 73 T-1(4); 74 T-4(1); 74 Pt-2(1); 74 T-10(1); 74 T-10(1); 74 T-11(1); 74 T-15(1); 74 T-24(3); 74

T-26(2); 74 T-29(1); 74 T-35(0); 74 T-42(10); 74 T-43(23); 74 T-61(3); 74 T-74(1); 90 T-1(1); 91 T-2(2). Eastern Pacific (*Zaca*) Expedition, Station 210 T-7(2); 219 T-2(1). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

Myctophum evermanni:

Gilbert, 1905, p. 597, pl. 70, fig. 2. (Holotype; 29 mm.; surface; south of Oahu, Hawaii).

Gilbert, 1908, p. 218. (11 specimens; ? mm.; ? fathoms; 1,300 to 1,500 miles southeast of Hawaii and to Marquesas).

Gilbert, 1913, p. 80. (15 specimens; ? mm.; surface; off southeast Japan).

Brauer, 1906, p. 162. (Key to species).

Weber, 1913, pp. 86, 87. (4 specimens; 20 to 48 mm.; ?—550 to 1,100 fathoms; East Indies).

Weber & Beaufort, 1913, p. 162, fig. 63. (Description and figure).

Jordan & Jordan, 1922, p. 11 (Name listed).

Fowler, 1928, p. 70. (10 specimens; ? mm.; ? fathoms; Hawaii).

Parr, 1928, p. 65. (Key to species).

Parr, 1929, p. 10. (Reexamination of type specimen, and considers it adequately described and figured by Gilbert).

Norman, 1929, p. 514. (1 specimen in British Museum, identified by Günther as *M. caninianum*, reexamined and referred to *M. evermanni;* ? mm.).

Myctophum laternatum Garman, 1899.

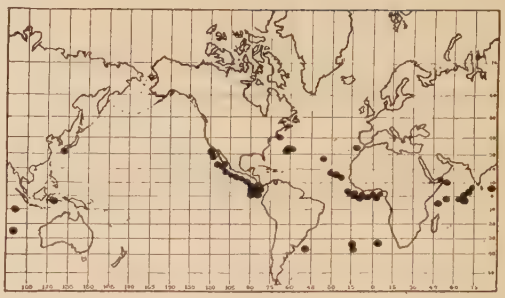
Specimens taken by Eastern Pacific Expeditions: 617 specimens; *Arcturus* Oceanographic Expedition; surface to 1,200 fathoms; between 2° 00′ S. and 6° 27′ N. Lat., and 81° 08′ and 91° 53′ W. Long.; lengths 8 to 28 mm.; between April 13 and June 13, 1925.

129 specimens; Templeton Crocker Expedition; 300 to 550 fathoms; between 20° 36′ and 26° 48′ N. Lat. and 108° 31′ and 113° 25′ W. Long.; lengths 5 to 27 mm.; between March 28 and April 29, 1936.

425 specimens; Eastern Pacific (*Zaca*) Expedition; 300 to 500 fathoms; between 5° 10′ and 17° 45′ N. Lat., and 78° 42′ and 103° 05′ W. Long.; lengths 5 to 28 mm.; between Nov. 23, 1937 and March 26, 1938.

Specimens previously recorded: 2,973 specimens; surface to ca. 2,734 fathoms; north and south Atlantic Oceans, Indian Ocean, Japan and East Indies, eastern Pacific from San Diego to Galápagos.

Photophore variation: This species shows very general bilateral symmetry in the distribution of anal photophores, only four out of 75 fish possessing different numbers on the two sides of the body. The dominant pattern is 6-3 (41 fish or 54.5 per cent.), and a second node at 7-3 (16 fish or 21 per cent.). The extremes are 5-3 and 8-3. As these last are exhibited by full-sized fish (26 mm.) and by young ones (14 mm.) respectively, it will be apparent that age has nothing to do with relative numbers of photophores.



Text-fig. 7. Distribution of *Myctophum laternatum.*

Luminous glands: One hundred and seventy fish selected at random from the entire catch were examined for luminous glands. This lot of fish resolved into 87 males and 35 females, the remaining 48 being juvenile, glandless fish. The antorbital photophore is a reliable sex differentiation character, the older males having it large and well-developed, while in the females it is somewhat smaller.

In the juvenile group, from 8 to 14 mm. no trace of glands was visible. In the males, from 17 to 20 mm. the gland is of medium extent, (1.5 to 1.7 mm. in a 17 mm. fish). In large males of 20 to 28 mm., the gland is elongate (averaging 2.5 mm. in a 25 mm. fish).

Sex proportions: If the above mentioned proportion of the sexes holds good among larger numbers, it means the females stand in the proportion of only two-fifths of the number of males.

Breeding: Four breeding females, Nos. 5642, 5671, 5718 and 5719, taken from May 11 to 25 off Cocos Island, eastern Pacific, average 25.5 mm. in length. The diameter of the eggs is .45 mm. and the average length of the ovaries is 6.5 mm. The number of eggs in each ovary vary from 181 to 210, approximately 400 eggs ready to be deposited in each female.

Vertical distribution: M. laternatum is peculiar in our hauls in that there is no sharp demarcation of vertical limits, no special emphasis on certain depths. The average fish per net is as follows: surface (14 fish per net), 300 fathoms (13), 400 (9), 500 (16), 600 (10), 800 (26), 1,000 (18), and 1,200 fathoms (15 fish per net).

Sociability: Twenty nets contained only a single fish each, but in 14 there were from

21 to 99. The average of these was 43 fish per net. The 602 fish in these 14 nets represent more than 50 per cent. of the whole, so the evidence for schooling is reasonably positive. The depths at which these larger numbers were taken are as follows: 300 fathoms (2 nets), 450 (1), 500 (8), and 600 fathoms (3 nets).

Study Material.

A total of 1,171 specimens was taken, as follows: *Arcturus* Expedition, Station 26 surface(1); 26 T-3(1); 33 Pt-1(1); 37 surface(4); 38 Pt-2(1); 39 T-4(12); 50 T-2(3); 50 T-3(13); 50 T-4(42); 59 T-3(10); 59 T-4(6); 59 T-5(5); 59 T-8(8); 59 T-9(2); 59 T-10(10); 59 Pt-1(1); 61 Pt-1(1); 61 T-3(11); 61 T-4(9); 63 T-1(7); 66 T-2(24); 66 T-3(12); 67 T-1(14); 68 T-3(45); 68 T-5(25); 68 Pt-1(28); 74 T-1(7); 74 T-3(2); 74 T-4(8); 74 T-5(9); 74 T-7(3); 74 T-9(8); 74 T-18(5); 74 T-20(6); 74 T-21(10); 74 T-71(6); 74 T-74(26); 74 Pt-1(3); 74 Pt-3(15); 74 V-2(14); 84 T-2(11); 84 T-3(1); 84 T-6(5); 84 T-7(3); 84 T-10(7); 84 T-19(8); 84 T-20(19); 84 T-21(3); 84 Pt-1(3); 84 Pt-4(1); 86 T-2(50); 86 T-5(15); 86 T-7(2); 86 T-8(7); 86 T-9(4); 86 T-10(2); 86 T-11(10); 86 Pt-1(5); 87 T-3(24); 87 T-5(17); 87 Pt-1(1). Templeton Crocker Expedition, Station 130 T-1(11); 134 T-3(1); 148 T-2(1); 148 T-3(1); 148 T-6(3); 158 T-2(14); 158 T-3(12); 158 T-4(3); 159 T-1(8); 159 T-2(2); 159 T-3(68); 165 T-3(5);. Eastern Pacific (*Zaca*) Expedition, Station 185 T-1(7); 185 T-2(4); 185 T-3(1); 210 T-1(99); 210 T-2(16); 210 T-3(7); 210 T-6(62); 210 T-7(79); 210 T-8(12); 210 T-10(22); 219 T-1 (51); 219 T-2(17); 227 T-1(21); 230 T-1(27). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Parr, 1928, p. 61).

Myctophum laternatum:

Garman, 1899, p. 267, pl. LVI, fig. 1. (7 specimens, including type; ? mm.; 200 to 1,168 fathoms; Gulf of California, 800 miles west of Costa-Rica, Gulf of Panama).

Gilbert, 1913, p. 77. (4 specimens; ? to 20 mm.; 300 fathoms; Japan; *partim* Bolin's *Diogenichthys scofieldi*).

Weber, 1913, p. 86. (2 specimens; 11 mm.; ? to 821 fathoms; Banda Sea north of Australia).

Weber & Beaufort, 1913, p. 156. (Description).

Regan, 1916, pp. 135, 139. (1 specimen; 8 mm.; surface; south Atlantic).

Tåning, 1918, p. 150, fig. 46. (Description of postlarval fish; 5 specimens; 5 to 20.3 mm.; ? to 875 fathoms; west of Tangiers).

Parr, 1928, pp. 61, 67. (Key to species; synonymy; discussion re *M. laternatum atlanticum;* 2 small specimens; 5,000 feet wire; near Bermuda).

Parr, 1931, p. 23, fig. 8. (2 specimens; ? mm.; 300 to 625 fathoms; cable; off west coast Mexico).

Parr, 1934, p. 42, fig. 1. (Examination and description of type specimens).

Norman, 1930, p. 324. (15 specimens; 11 to 27 mm.; ? to 1,368 fathoms; south Atlantic).

Roule & Angel, 1930, p. 48. (1 specimen; 16 mm.; surfaace to 2,734 fathoms; between Canary and Azores Islands).

Beebe, 1929, p. 15. (1 specimen; ? mm.; ? fathoms; Hudson Gorge, northwest Atlantic).

Beebe, 1937, p. 205. (Preliminary list of 2,853 specimens; 9 to 22 mm.; 100 to 1,000 fathoms; Bermuda).

M. (Myctophum) laternatum:

Brauer, 1904, p. 388 (Key to species).

Brauer, 1906, p. 178, figs. 90-91. (63 specimens; ? to 22 mm.; ? fathoms; west coast Africa at Cape Verde, Sierra Leone, Gulf of Guinea, Indian Ocean, Sumatra, Bay of Bengal, Ceylon, Seychelles and Zanzibar, Gulf of Aden).

Zugmayer, 1911, p. 23. (1 specimen; 20 mm.; surface to 984 fathoms; Atlantic Ocean near Gibraltar).

Pappenheim, 1914, p. 193. (18 specimens; 11 to 19 mm.; 500 to 3,000 m. wire).

M. laternatum atlanticum:

Tåning, 1928, p. 56. (Key to new subspecies; 1 specimen; ? mm.; ? fathoms; Gibraltar).

Tåning, 1932, p. 118, figs. 1-2. (Description and synonymy).

LeGendre, 1934, p. 337. (Key to species).

Parr, 1934, p. 57. (Description).

Diogenichthys laternatus:

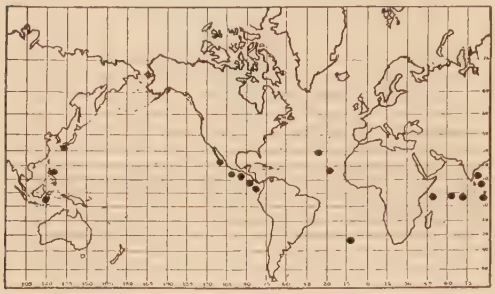
Bolin, 1939, pp. 92, 119, figs. 14, 15. (Key to species; detailed description; synnonymy; 15 specimens; 11.9 to 25.1 mm.; lower California and Japan).

Myctophum pterotum (Alcock, 1890).

Specimens taken by Eastern Pacific Expeditions: 6 specimens; Eastern Pacific (*Zaca*) Expedition; surface to 500 fathoms; between 7° 08′ and 16° 05′ N. Lat., and 81° 57′ and 98° 17′ W. Long.; lengths 20 to 43 mm.; taken between Nov. 30, 1937 and March 20, 1938.

Specimens previously recorded: 180+ specimens; ? to 64 mm.; ? to 3,000 metres wire; mid- and south Atlantic and Indian Oceans, Borneo, Philippines, Japan, eastern

Pacific from tip of lower California to Panama.



TEXT-FIG. 8. Distribution of *Myctophum pterotum.*

Photophore variation: Both Bolin's and Parr's keys give 6-4 as the number of anal photophores of this species. Two of our six fish present exceptions to this combination, one of 38 mm. with 7-4, and another 43 mm. in length 6-4, 5-4.

Luminous glands: No luminous sex glands are visible on any of the specimens. Bolin (1939, p. 118) examined 28 specimens from the *western* Pacific measuring 30.8 to 53.1 mm. and states that "in most specimens, even the largest ones, no caudal luminous patches are developed."

Vertical distribution: Four specimens (34 to 43 mm.) taken at the surface after dark; two specimens (20 to 24 mm.) taken in a 500-fathom haul.

STUDY MATERIAL.

A total of 6 specimens was taken, as follows: Eastern Pacific (*Zaca*) Expedition, Station 193 L-1(3); 210 L-1(1); 225 T-1(2). For detailed trawling data, refer to *Zoologica,* Vol. XXIII, pp. 287-298.

REFERENCES AND SYNONYMY.

(Synonymy accepted according to Bolin, 1939, p. 116).

Scopelus (Myctophum) pterotus:

Alcock, 1890, p. 217. (60 specimens, including type; ? mm.; 98 to 102 fathoms; Bay of Bengal).

Alcock, 1896, p. 333. (Listing of previous reference).

Myctophum pterotus:

Goode & Bean, 1895, p. 5. (Reference to 60 specimens of Alcock's, listed above).

Myctophum pterotum:

Garman, 1899, p. 401. (Listing of Alcock's material).

Fowler, 1928, p. 70. (Description; synonymy).

Norman, 1929, pp. 512, 513, fig. 2. (Synonymy; reexamination of 8 specimens, including some of the types).

Parr, 1928, pp. 60, 67. (Key to species; synonymy; discussion of synonymy: *M. pterotum* vs. *M. fibulatum*).

Parr, 1929, p. 7. (Reexamination of type specimens; synonymy).

Parr, 1831, p. 22. (2 specimens; ? mm.; 525 to 1,800 fathoms; off west coast of Mexico).

Weber, 1913, pp. 86, 670. (5 specimens; 20 to 38 mm.; 6 fathoms; Macassar Straights near Borneo).

Weber & Beaufort, 1913, p. 157. (Description and synonymy).

Myctophum gilberti:

Evermann & Seale, 1907, p. 55, fig. 1. (4 specimens, including type; 54 to 64 mm.; ? fathoms; Philippines).

Gilbert, 1913, p. 81. (65 specimens; ? to 70 mm.; collected in market at Kagoshima, Japan).

Myctophum (Myctophum) pterotum:

Brauer, 1906, p. 182, figs. 93, 94. (6 specimens; ? to 61 mm.; 821 to 1,368 fathoms; Indian Ocean).

Barnard, 1925, p. 242. (Description).

Pappenheim, 1914, p. 193. (10 specimens; 13 to 18 mm.; ? to 3,000 metres wire; mid-north Atlantic).

Myctophum pterotum panamense:

Tåning, 1932, p. 129, fig. 3. (? specimens; 28 to 36 mm.; ? fathoms; Gulf of Panama).

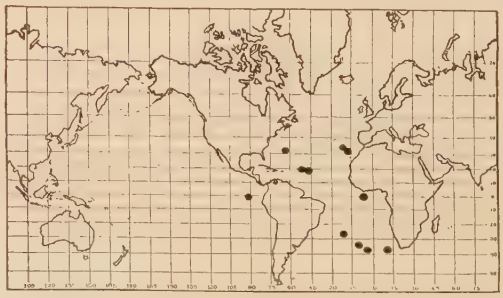
Myctophum (Benthosema) pterotum:

Bolin, 1939, pp. 92, 116, fig. 13. (Key to species; synonymy; description; 28 specimens; 30.8 to 53.1 mm.; ? fathoms; Japan, Philippines).

Myctophum rarum (Lütken, 1892).

Specimens taken by the Eastern Pacific Expeditions: 1 specimen; *Arcturus* Oceanographic Expedition; 500 fathoms; 0° 17′ S. Lat., 91° 34′ W. Long.; length 28 mm.; June 9, 1925.

Specimens previously recorded: 16 specimens; 21 to 40 mm.; ? to 1,640 fathoms; north and south Atlantic. Our specimen is the first to be recorded from the Pacific.



TEXT-FIG. 9. Distribution of *Myctophum rarum.*

Photophore variation: The single specimen corresponds in all details with the description of the species, having only two SAO and with a greater space between the first and second anterior anal photophores than between the others.

Luminous glands: This specimen, a male, has a very long and definite supracaudal gland, five plates running together with only faintly distinct divisions.

Study Material.

One specimen was taken, as follows: *Arcturus* Expedition, Station 84 Pt-3(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

References and Synonymy.

(Synonymy accepted according to Parr, 1928, p. 59).

Scopelus (Rhinoscopelus) rarus:

Lütken, 1892a, p. 246. (Key to species; description of type specimens; 4 specimens; 38 to 40 mm.; ? fathoms; north and south Atlantic).

?Rhinoscopelus rarus:

Goode & Bean, 1895, p. 91. (Description).

Jordan & Evermann, 1896, p. 569. (Description).

Myctophum rarum forma integer:

Brauer, 1904, p. 390. (Key to species; 1 specimen; 23 mm.; 1,640 fathoms; Gulf of Guinea).

Brauer, 1906, p. 204. (Further description).

Pappenheim, 1914, p. 197. (1 specimen; 31 mm.; 1,640 fathoms; south Atlantic).

LeGendre, 1934, p. 337. (Key to species).

?Rhinoscopelus (Loweina) rarus:

Fowler, 1925, No. 162, p. 2. (Listing only as new sub-genus "Loweina").

Myctophum rarum:

(Not Brauer 1906, pp. 163, 404; not Barnard 1925, p. 245).

Parr, 1928, p. 59. (Key to species and synonymy).

Tåning, 1928, p. 55. (Key to species).

Tåning, 1932, p. 155. (Description and figure).

LeGendre, 1934, p. 337. (Key to species).

Beebe, 1937, p. 205. (Preliminary list; 10 specimens; 21 to 26 mm.; 500 to 1,000 fathoms; Bermuda).

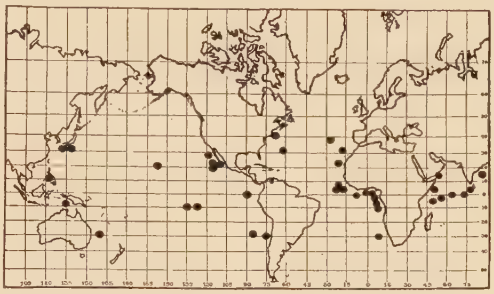
Myctophum reinhardti (Lütken, 1892).

Specimens taken by Eastern Pacific Expeditions: 131 specimens; *Arcturus* Oceanographic Expedition; surface to 1,000 fathoms; between 2° S. and 2° 12′ N. Lat., and 88° 11′ and 91° 53′ W. Long.; lengths 10 to 17 mm.; between April 14 and June 13, 1925.

24 specimens; Templeton Crocker Expedition; surface to 400 fathoms; between 18° 44′ and 25° 25′ N. Lat., and 108° 49′ and 110° 33′ W. Long.; lengths 13 to 51.5 mm.; between April 18 and May 7, 1936.

1 specimen; Eastern Pacific (*Zaca*) Expedition; surface; 28° 42′ N. Lat., and 117° 50′ W. Long.; length 51 mm.; Nov. 8, 1937.

Specimens previously recorded: 259 specimens; ? to 57 mm.; surface to 2,187 fathoms; north west Atlantic, Azores, west and east coasts of Africa, Indian Ocean, Japan, Australia, mid-Pacific and eastern Pacific from lower California south to mid-Chile.



Text-fig. 10. Distribution of *Myctophum reinhardti.*

Photophore variation: Anal photophore counts were made on 121 fish, the others being two rubbed or otherwise damaged. Photophores are distinct on fish as small as 8 mm. in length. The count reveals two dominant, numerical nodes, 5-6 and 6-7, comprising 52 fish and 43 per cent., and 36 fish or 30 per cent. of the whole, respectively. Extremes in numbers are 5-6 and 6-9, with only two fish showing the bilateral numerical asymmetry of 6-6, 6-5 and 6-6, 7-5.

Luminous glands and sex proportions: All of the 131 specimens taken on the *Arcturus* Expedition are young. Of the Templeton Crocker Expedition catch of 24, only four showed developed, sexual, luminous glands; three males of 46, 51 and 51.5 mm. with supracaudal glands well developed, and one female of 40 mm. with two small, separate, infracaudal glands.

Vertical distribution: The vertical distribution of the 156 specimens is as follows: surface (58 fish), 300 fathoms (11 fish), 400 (28), 500 (35), 600 (4), 800 (9) and 1,000 fathoms (11 fish).

This proportion of surface captures of 58 fish or only 37 per cent. of the whole is unusual, and would seem to indicate that this species lives at greater depths than other myctophids.

Sociability: Schooling is indicated by the fact that 62 fish, or 40 per cent. of the total were taken in four nets, whereas the remaining 94 were distributed among 34 nets, of which a single fish occurred in each of 15 nets.

Food: Our only notes on food is the record of copepods in eight fish, amphipods in three, and euphausids in three other fish.

Study Material.

A total of 156 specimens was taken, as follows: *Arcturus* Expedition, Station 41 T-1(7); 49 T-2(1); 50 T-5(6); 52 T-1(2); 57 T-1(17); 78 T-1(4); 84 T-2(1); 84 T-8(3); 84 T-10(3); 84 T-10(6); 84 T-14(3); 84 Pt-3 (1); 84 T-19(1); 84 T-19 (1); 84 T-20(1); 84 T-21(2); 86 T-2 (20); 86 T-2 (2); 86 T-4 (6); 86 T-5 (8); 86 T-7(1); 86 T-9(1); 86 T-10(1); 86 Pt-1 (2); 86 T-11(3); 87 T-2(7); 87 T-3 (12); 87 T-5(1). Templeton Crocker Expedition, Station 149 L-1 (1); 158 T-2(1); 159 T-1 (1); 159 T-2 (2); 138 L-1(13); 160 L-1 (1); 162 L-1(5). Eastern Pacific (*Zaca*) Expedition, Station 177 L-1(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 113).

Scopelus reinhardti:

Lütkin, 1892, p. 257, fig. 16. (*Partim:* 2 specimens, including type; ? to 43 mm.; ? fathoms, off Madeira and Liberia).

Myctophum atratum:

Garman, 1899, p. 268. (? specimens; ? mm.; 1,218 fathoms; southern part of Gulf of California).

Myctophum braueri:

Gilbert, 1905, p. 598. (Description; 17 specimens including type of 57 mm.; no other lengths given; surface; Hawaiian Islands).

Myctophum lutkeni:

Gilbert, 1905, pl. 70, fig. 1. (lapsus calami pro *Myctophum braueri*).

Myctophum reinhardti:

Goode & Bean, 1895, p. 74. (Description).

Waite, 1904, pp. 154, 194. (2 specimens; 35 and 45 mm.; ? fathoms; Australia).

Gilbert, 1908, p. 219. (6 specimens; young; ? fathoms; 300 miles east of Marquesas).

Gilbert, 1913, p. 80. (3 specimens; young; surface; off southwest coast of Japan).

Jordan & Jordan, 1925, p. 11. (References and synonymy).

Tåning, 1928, p. 57. (Key to species).

Parr, 1928, p. 66. (Key to species, synonymy).

Fowler, 1928, p. 70. (Synonymy).

Beebe, 1929, p. 16. (4 specimens; ? mm.; surface to 800 fathoms; Hudson Gorge, northwest Atlantic).

Beebe, 1937, p. 205. (Preliminary list; 72 specimens; 11 to 35 mm.; 100 to 1,000 fathoms; Bermuda).

Myctophum benoiti reinhardti:

Brauer, 1904, p. 388. (Key to species).

Brauer, 1906, p. 185. (100 specimens; ? to 25 mm.; 670 to 2,187 fathoms; Gulf of Guinea, southwest Africa, Bay of Bengal, Seychelles Islands, Gulf of Aden, Ceylon, Indian Ocean, west coast of Chile).

Weber, 1913, p. 86. (5 specimens; 9 to 16 mm.; surface to 825 fathoms; Banda Sea, Almahera Sea, East Indies).

Weber & Beaufort, 1913, pp. 152, 155. (Key to species; synonymy and description).

Pappenheim, 1914, p. 193. (16 specimens; 15 to 32 mm.; ? to 1,642 fathoms; south Atlantic).

Barnard, 1925, p. 242. (References and brief description).

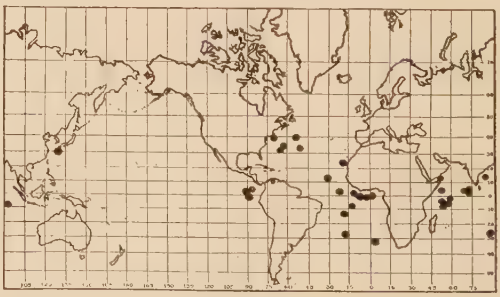
Myctophum (Hygophum) reinhardti:

Bolin, 1939, pp. 93, 113-116, fig. 12. (Key; synonymy; description; 31 specimens, of which 7 were paratypes of *M. braueri,* Gilbert; 17.7 to 31.2 mm.; ? fathoms; Hawaiian Islands and Philippines).

Myctophum valdiviae Brauer, 1904.

Specimens taken by Eastern Pacific Expeditions: 35 specimens; *Arcturus* Oceanographic Expedition; 300 to 700 fathoms; between 6° 27′ N. Lat., and 0° 17′ S. Lat., and 91° 53′ and 84° 35′ W. Long.; lengths 8 to 23 mm.; between May 1 and June 13, 1925.

Specimens previously recorded: 924 specimens; ? to 23 mm.; surface to 2,260 fathoms; north and south Atlantic Ocean, west and east coasts of Africa, Indian Ocean, Japan and eastern Pacific off Cocos and Galápagos Islands.



Text-fig. 11. Distribution of *Myctophum valdiviae.*

Photophore variation: All 35 specimens were in rather bad condition, with nearly all the anal photophores rubbed or torn away. The species is easily identified without them, it being the only *Myctophum* which has the four upper photophores *above* the lateral line. Because of the generally poor condition of the anal photophores,

nothing of interest could be determined in regard to their variation.

Luminous glands: The 35 fish measured from 8 to 23 mm. Of these 20 showed no signs of supracaudal luminous glands, and (with the exception of one fish of 16 mm.) were all 12 mm. or under in length. The distinction between male and female glands is not satisfactory enough to class the remaining 16 fish as anything but nearly or not quite adult.

Breeding: Fish No. 5569, a female of 22 mm., was taken 100 miles south of Cocos Island, on May 1. The ovaries were 3.5 mm. in length and the diameter of the eggs .28 mm. The total number of eggs about to be laid was 120.

Vertical distribution: All 35 fish were taken at depths from 300 to 700 fathoms; none at the surface. The relative numbers were 300 fathoms (4 fish); 400 (11); 500 (14); 600 (5); and 700 fathoms (1 fish).

Sociability: With only 35 specimens at hand it is difficult to hazard any opinion as to schooling, especially as 8 fish were taken in one net, and 8 others each in a single net.

Food: Copepods and amphipods were found in several stomachs.

Study Material.

A total of 35 specimens was taken, as follows: *Arcturus* Expedition, Station 59 T-4(1); 59 T-5(2); 59 T-9(1); 59 Pt-2(3); 61 T-3(3); 68 T-3(2); 74 T-8(1); 74 T-71 (2); 74 T-74(2); 74 T-78(1); 84 T-1(1); 84 T-8(1); 84 T-20(1); 86 T-2(5); 86 T-8(1); 87 T-2(8). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

References and Synonymy.

(References accepted according to Parr, 1928, p. 57).

Myctophum valdiviae:

Brauer, 1904, p. 398, fig. 6. (Preliminary listing of 68 specimens, including type; details in following reference).

Brauer, 1906, p. 206, fig. 127. (68 specimens; 8 to 23 mm.; 274 to 2,260 fathoms; Atlantic Ocean, south of Canary Islands, Gulf of Guinea, 500 miles west of southwest Africa, Indian Ocean, between Aden and Madagascar, mid-ocean between Ceylon and Zanzibar, Cocos Island, Bay of Bengal).

Gilbert, 1913, p. 84. (1 badly injured specimen; ? mm.; ? to 300 fathoms; Japan).

Tåning, 1918, p. 151, fig. 47. (Description of post-larvae; 4 specimens; 1 adult and 3 post-larvae; 4.7 to 15 mm.; ? fathoms; mid-ocean northwest and southwest of Bermuda).

Tåning, 1928, p. 57. (Key to species).

Tåning, 1932, p. 121, figs. 1, 2. (Description).

Parr, 1928, p. 57. (Key to species; synonymy).

LeGendre, 1934, p. 335. (Key to species).

Beebe, 1929, p. 15. (4 specimens; ? mm.; ? fathoms; Hudson Gorge, northwest Atlantic Ocean).

Beebe, 1937, p. 205. (Preliminary list; 846 specimens; 9 to 23 mm.; 300 to 1,000 fathoms; Bermuda).

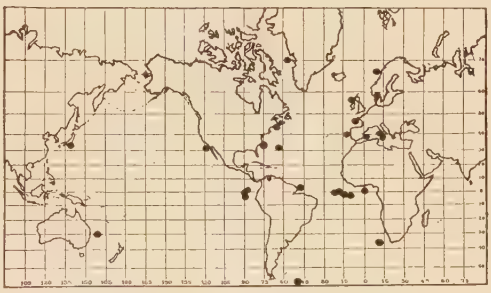
Myctophum (Myctophum) valdiviae:

Pappenheim, 1914, p. 194. (16 specimens; 9 to 24 mm.; 800 to 3,000 metres; north and south Atlantic).

Lampanyctus elongatus (Costa, 1844).

Specimens taken by Eastern Pacific Expeditions: 3 specimens; *Arcturus* Oceanographic Expedition; surface to 700 fathoms; between 2° 00′ S. Lat. and 4° 50′ N. Lat., and between 87° 00′ and 89° 48′ W. Long., lengths, 25, 72.5 and 83 mm.; taken April 3 and 23, May 31, 1925.

Specimens previously recorded: 706 specimens; ? to 153 mm.; surface to 2,600 fathoms; western Atlantic from Greenland south to Cape Horn, eastern Atlantic from mid-Norway and Mediterranean south to Cape of Good Hope, Australia, Japan, eastern Pacific from San Diego to Galápagos. Our specimens extend the range to the Galápagos and Cocos Islands. A widely distributed but rare species.



Text-fig. 12. Distribution of *Lampanyctus elongatus.*

General data: Our three specimens show the following details: Cat. No. 5214a, sex uncertain, 25 mm. in length, anal photophores 9-6, 9-5. Cat. No. 5429, a female, 83 mm., anal photophores 8-?, 8-?, taken April 23, 1925, ovaries injured but many eggs visible; not countable but almost ready to be deposited. Cat. No. 6053, female, 72.5 mm.; anal photophores 8-6, 9-6. Two small, infracaudal luminous glands just appearing. Eggs undeveloped. Anal photophore counts of other authors are 7-9, 6-7; 7-9, 5-7; and 9-6, 6-7.

General color: Cornea over pupil reflecting iridescent green in all illuminations; iris dark brown except for the inferoposterior third which is brilliant coppery gilt; body in general brownish-black; glints of blue and green on opercles and body, but

scales are colorless. All large, round photophores are pink, smaller ventral ones silvery. All light given off is decidely pink.

Food: The 83 mm. female had eaten two amphipods and one euphausid.

Study Material.

A total of 3 specimens was taken, as follows: *Arcturus* Expedition, Station 33 Pt-1 (1); 52 T-1(1); 74 T-35(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 151).

Scopelus elongatus:

Costa, 1844, p. 2, pl. 38. (Original description; reference not seen; Naples, fide; Jordan & Evermann, 1896).

Canestrini, 1870, p. ? (Reference not seen).

Steindachner, 1881, p. 397. (Description and discussion of synonymy of ? specimens in Vienna Museum; 135 to 150 mm.; ? depth, ? locality).

Vinciguerra, 1885, p. 462. (Description and synonymy).

Raffaele, 1889, p. 184, fig. 11. (Discussion of synonymy).

Lilljeborg, (1884-91), p. ? (Reference not seen).

Lütken, 1892a, p. 264. (Description and key to species; 4 specimens; about 80 to 84 mm.; ? fathoms; Greenland, Gulf of Guinea and south of Cape of Good Hope).

Koehler, 1896, p. 506. (1 specimen; 62 mm.; 760 fathoms; off Lorient, France).

Holt & Byrne, 1905, p. 23. (1 specimen; ? mm.; 350 fathoms; northeast coast of Ireland).

Holt & Byrne, 1911, p. 24, fig. 7. (Description and synonymy).

Scopelus crocodilus:

Cuvier & Valenciennes, 1849, vol. 20, p. 332. (Reference).

Cuvier & Valenciennes, 1849, vol. 22, p. 447. (Description).

Scopelus pseudocrocodilus:

Moreau, 1891, p. 84, fig. 227. (Description).

Brauer, 1906, p. 233. (Synonymized with *M.* (*Lampanyctus*) *elongatum*).

Scopelus kroyeri:

Malm, 1863, p. 100. (Reference not seen).

Brauer, 1906, p. 232, figs. 152, 153. (Synonymizes this with *M.* (*Lampanyctus*) *elongatum*).

Winther, 1879-80, p. 42. (Brief reference).

Collet, 1880, p. 162. (1 specimen, found in stomach of *gadus morrha*).

Scopelus resplendens:

Günther, 1864, vol. 22, p. 415. (Description and snyonymy).

Scopelus (*Notoscopelus*) *elongatus:*

Günther, 1864, vol. 22, p. 415. (Description and synonymy).

Notoscopellus brachychier: (error in type).

Eigenmann & Eigenmann, 1889, p. 126. (3 specimens; ? mm.; 45 fathoms; Cortez Bay, San Diego).

Notoscopelus brachychier:

Eigenmann & Eigenmann, 1890, p. 23. (Reference).

Notoscopelus resplendens:

Goode & Bean, 1895, p. 83, fig. 94. (Description and key).

Notoscopelus elongatus:

Goode & Bean, 1895, p. 83. (Description and key).

Bolin, 1939, pp. 93, 151, 152, fig. 29. (Key; synonymy and description; 2 specimens; 110 and 113.5 mm.; ? fathoms; Misaki Sea, Japan).

Notoscopelus quercinus:

Goode & Bean, 1895, p. 83, fig. 97. (3 specimens; ? to 125 mm.; ? to 781 fathoms; north Atlantic, off Cape Cod, Massachusetts, and coast of Virginia).

Notoscopelus ejectus:

Waite, 1904, p. 150, pl. 18, fig. 2. (1 specimen; 40.5 mm.; ? fathoms; Australia).

Catablemmella brachychir:

Eigenmann & Eigenmann, 1890, p. 23. (Reference).

Scopelus (*Lampanyctus*) *elongatus*:

Lütken, 1892, p. 233. (Reference to specimens described under *Scopelus elongatus*).

Carus, 1889-1893, p. 565. (Description).

Macrostoma angustidens:

Jordan & Evermann, 1896, p. 555. (Description).

Macrostoma quercinum:

Jordan & Evermann, 1896, p. 554. (Description).

Macrostoma brachychir:

Jordan & Evermann, 1898, p. 2826. (Name listed).

Macrostoma quercinum japonicum:

Tanaka, 1908, p. 5, pl. 1, fig. 3. (Description).

Macrostoma japonicum:

Tanaka, 1911, p. 59, pl. 15, fig. 51. (Redescription of type specimen reported in previous reference).

Myctophum elongatum:

Collet, 1884, p. 104. (Description; discussion of synonymy; 5 specimens; 128 to 145 mm.; ? fathoms; coast of Norway, Trondheim and vicinity).

Smitt, 1895, p. 937, fig. 234. (Detailed description).

Sanzo, 1918a, p. 4. (Description of young).

Myctophum (Lampanyctus) elongatum:

Brauer, 1906, p. 232, figs. 152, 153. (Key; description; synonymy; 7 specimens; 15 to 125 mm.; 380 to 2,187 fathoms; Gulf of Guinea, west of Cape Colony).

Fage, 1910, p. 15, fig. 13. (Description).

Zugmayer, 1911, p. 37. (1 specimen; 57 mm.; 2,600 fathoms; off west coast of Portugal).

Pappenheim, 1914, p. 196. (6 specimens; 22 to 29 mm.; ? to 1,642 fathoms; south Atlantic).

Alaejos, 1919. p. ? (Reference not seen).

Barnard, 1925, vol. 21, p. 238. (Description).

Myctophum (Lampanyctus) quercinum:

Brauer, 1906, p. 166. (Key to species).

Lampanyctus japonicus:

Gilbert, 1913, p. 99. (Brief discussion).

Lampanyctus resplendens:

Richardson, 1844, p. 42, pl. 27, figs. 16-18. (1 specimen; 112 mm.; ? fathoms; ? locality).

Matsubara, 1938, p. 53, fig. 10. (Description; 3 specimens; 123 to 153 mm.; about 150 fathoms; Japan).

Lampanyctus elongatus:

Gilbert, 1913, p. 99. (Reference; discussion of *L. japonicus*).

Tåning, 1918, pp. 103-106, figs. 40, 41. (Detailed description of both young and adults; distribution map; propagation etc.; 651 specimens; ? to 60 mm. surface to 670 fathoms; western Meditteranean and Atlantic Ocean).

Tånning, 1928, p. 64. (Key to species).

Tåning, 1932, p. 124, figs. 1, 2. (Description).

Parr, 1928, p. 80. (Key to species; synonymy).

Parr, 1929, p. 14. (Additional synonymy).

Norman, 1930, p. 329. (4 specimens; 30 to 53 mm.; surface to 547 fathoms; mid and south Atlantic).

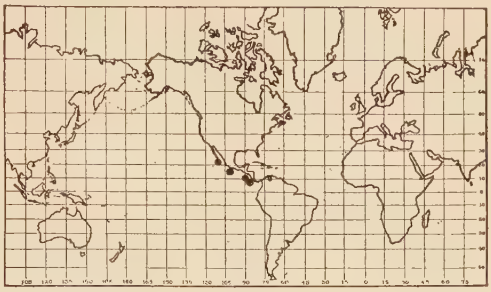
LeGendre, 1934, p. 343. (Key to species).

Beebe, 1937, p. 204. (Preliminary list; 11 specimens; 13 to 30 mm.; 400 to 1,000 fathoms; Bermuda).

Lampanyctus idostigma Parr, 1931.

Specimens taken by Eastern Pacific Expeditions: 12 specimens; Eastern Pacific (*Zaca*) Expedition; 300 to 500 fathoms; between 8° 03′ and 9° 12′ N. Lat., and 83° 12′ and 85° 10′ W. Long.; lengths 16 to 37 mm.; between Feb. 7 and March 10, 1938.

Specimens previously recorded: 27 specimens; 50 to 76 mm.; 100 to 200 fathoms; Eastern Pacific from tip of Lower California to Nicaragua. Our collection extends the range to southern Costa Rica.



TEXT-FIG. 13. Distribution of *Lampanyctus idostigma*

Anal photophores: Our 12 specimens, ranging from 16 to 37 mm.; are all too immature to be sexed. The photophore arrangement is as follows: (5 specimens) 6-6; (4) 5-6; (2) 5-6, 6-6; and (1 specimen) 6-6, 6-7.

General data: Three fish were taken at 300 fathoms and nine at 500 fathoms. There is no hint of schooling as the 12 fish were scattered among eight nets. All the evidence points to this species living in deep water. Our fish were all taken at two localities off Costa Rica, 150 miles apart.

STUDY MATERIAL.

A total of 12 specimens was taken, as follows: Eastern Pacific (*Zaca*) Expedition, Station 210 T-1(2); 210 T-3(1); 210 T-6 (1); 210 T-7(1); 210 T-8(3); 210 T-10(1); 219 T-1(1); 219 T-2(2). For detailed trawling data, refer to *Zoologica*, Vol. XXIII, pp. 287-298.

REFERENCES AND SYNONYMY.

Lampanyctus idostigma:

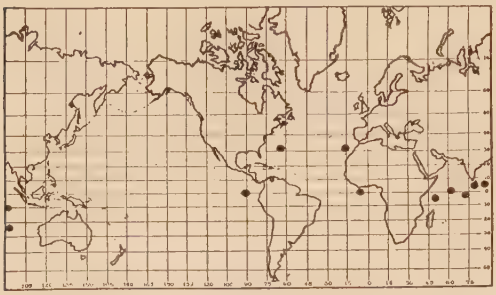
Parr, 1931, p. 32, fig. 13. (27 specimens, including type; 50 to 76 mm.; 300 to 625 fathoms cable; Pacific coast of Nicargua, off southern Mexico, Gulf of California).

Bolin, 1939, pp. 93, 138, fig. 22. (Key to species; redescription of 2 of Parr's specimens).

Lampanyctus longipes (Brauer, 1906).

Specimens taken by Eastern Pacific Expeditions: 1 specimen; *Arcturus* Oceanographic Expedition; 500 fathoms; at 0° 40′ N. Lat., and 91° 47′ W. Long., length 21 mm.; taken June 12, 1925.

Specimens previously recorded: 18 specimens; surface to 1,230 fathoms; 11 to 32 mm.; rare but widely distributed. Bermuda, west coast of Africa, Indian Ocean, Bay of Bengal. Our record is the first for the Pacific, and was off the Galápagos.



TEXT-FIG. 14. Distribution of *Lampanyctus longipes.*

Our fish, 21 mm., was too young for sexing; its anal photophore count was 5-3, 5-3.

STUDY MATERIAL.

One specimen was taken, as follows: *Arcturus* Expedition, Station 86 T-2(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

REFERENCES AND SYNONYMY.

(Synonymy accepted according to Parr, 1928, p. 82).

M. (Lampanyctus) longipes:

Brauer, 1906, p. 236, fig. 155. (Original description; 14 specimens, including types; 11 to 32 mm.; surface to 1,230 fathoms; Madeira, Gulf of Guinea, Seychelles Islands, Bay of Bengal, south of Ceylon, Indian Ocean).

Lampanyctus pyrsobolus longipes:

Tåning, 1928, p. 65. (Key to species).

LeGendre, 1934, p. 344. (Key to species).

Lampanyctus longipes:

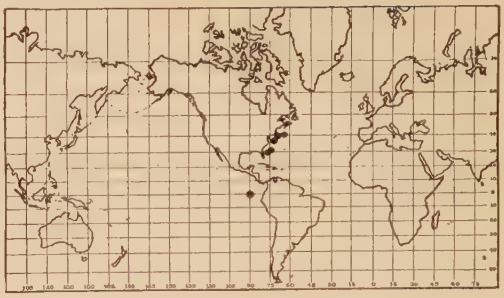
Parr, 1928, p. 82. (Key to species; synonymy).

Beebe, 1937, p. 204. (Preliminary list; 4 specimens; 12 to 20 mm.; 800 to 1,000 fathoms; Bermuda).

Lampanyctus macdonaldi (Goode & Bean, 1895).

Specimens taken by Eastern Pacific Expeditions: 3 specimens; *Arcturus* Oceanographic Expedition; 400 fathoms; between 0° 00′ equator and 91° 53′ W. Long.; lengths 20 to 29 mm.; June 13, 1925.

Specimens previously recorded: ? specimens; lengths ? to 154 mm.; ? to 1,467 fathoms; northwestern Atlantic. Our specimens are the first recorded from the Pacific Ocean.



TEXT-FIG. 15. Distribution of *Lampanyctus macdonaldi.*

Photophore variation: Our three specimens, (Cat. No. 6365a), taken 21 miles north of Narborough, Galápagos, show the following anal photophore count: 1 specimen 20 mm. 6-6-4 on both sides; 1 specimen 27 mm. 6-6-4 and 6-7-4; 1 specimen 29 mm. 6-6-4 on both sides.

STUDY MATERIAL.

A total of 3 specimens was taken, as follows: *Arcturus* Expedition, Station 87 T-2 (3). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

REFERENCES AND SYNONYMY.

(Synonymy accepted according to Parr, 1929, p. 20).

Nannobrachium macdonaldi:

Goode & Bean, 1895, p. 94, fig. 110, pl. 29. (Original description; ? specimens, including type; ? to 154 mm.; ? to 1,467 fathoms; northwestern Atlantic).

Jordan & Evermann, 1896, vol. 1, p. 563. (Description).

Tåning, 1928, p. 69. (Reference to synonymy).

Lampanyctus macdonaldi:

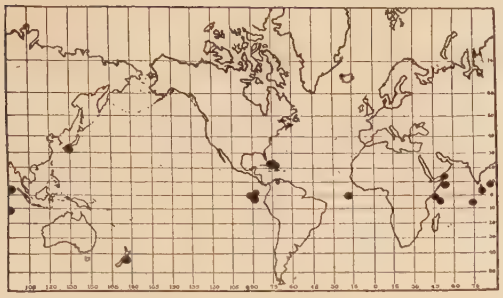
Parr, 1929, p. 20, fig. 9. (Redescription of type specimen and synonymy).

Lampanyctus macropterus (Brauer, 1904).

Specimens taken by Eastern Pacific Expeditions: 150 specimens; *Arcturus* Oceanographic Expedition; surface to 1,000 fathoms; between 2° 00′ S. and 4° 50′ N. Lat., and 87° 00′ and 91° 53′ W. Long.; lengths 16 to 70 mm.; taken between April 22 and June 13, 1925.

Specimens previously recorded: 29 specimens; ? to 105 mm.; surface to 1,642 fathoms; West Indies, south Atlantic, north Indian Ocean, Bay of Bengal, Japan. Our specimens, all from the Galápagos, are the first recorded from the eastern Pacific.

Photophore variation: Photophore count of 137 fish shows them in general to be symmetrical, 30 per cent. or 42 specimens hav-



TEXT-FIG. 16. Distribution of *Lampanyctus macropterus.*

ing 5-9 anal photophores; 27 per cent. or 37 specimens having 5-8 anal photophores, and the balance are divided into the following combinations: 4-8, 4-10, 4-11, 5-7, 5-10, 5-11, 6-8, 6-9, and the asymmetrical combinations of 5-7, 4-8; 5-8, 5-7; and 5-9, 5-7.

Development: All of the 150 specimens were measured with this result: 84 fish or 56 per cent. were 16 to 36 mm. and 66 fish or 44 per cent. from 37 to 70 mm. in length.

Eggs: Three females (Cat. No. 6057), measuring 53, 55 and 59 mm. had eggs present, while another female, measuring 50 mm. (same Cat. No.) was without developed eggs. These were taken at Station 74, T-41, 42, 60 miles south of Cocos Island on June 1, 1925.

Vertical distribution: Of the entire catch, 46 fish or 33 per cent. were taken at the surface. Of the remainder, 70 per cent. were brought up from 400 and 500 fathoms. An unusual fact is that 11 of the 46 surface fish were taken in full sunlight, in a haul made from 9.30 to 11.00 A.M. These 11 were all young (18 to 24 mm.), while the remaining surface fish taken after dark were much larger (35 to 58 mm.) more nearly adult.

Sociability: Schooling is definitely indicated. Seventy-five fish or 50 per cent. were taken in five nets, an average of 15 fish to a net, while the rest were distributed among 24 nets, averaging two and a half fish to each.

Food and Anatomy: On May 24, 1925, sixty miles south of Cocos Island, at 8.00 to 8.30 P.M. from a rainy and a rough sea, I drew a surface net containing among other fish 13 *Lampanyctus macropterus.* These were large (50 to 70 mm.) and very vigorous and active. A male of 65 mm. appeared to have gorged itself, and I dissected it for food. The swim bladder was fully inflated, silvery white and 20 mm. long. The anterior end was rounded and 5.5 mm. in diameter. This thickness was sustained posteriorly for 12 mm. when the organ tapered rapidly for the posterior 8 mm. to end in a fine point. The lining of the body cavity was slightly pigmened, while the stomach, unlike any of the other organs, was jet black.

The fish had already fed well although it was so early in the evening. The contents comprised 9 fish eggs, 1 mollusk egg-mass, 1 small sagitta, 5 young euphausids, 3 hyperid amphipods, 6 small calanids, and 1 *Eucalanus elongatus.*

Luminescence and viability: The following notes are from my Journal made on May 25, 1925, upon fish from a surface haul made sixty miles south of Cocos Island, in the darkroom of the *Arcturus.* There were a number of *Noctiluca* and *Sapphirina* in the water but we had little trouble in differentiating between their light and that of the myctophids. We tested the fish in artificial sea water but if anything their light was exhausted sooner than in the warmer, normal salt water. There was no reaction to three drops of ammonia, nor to a slight shock of electricity sent through the water. When sent through the fish they died immediately.

One observation made again and again during the evening was of an obliterative flashing, repeated so identically that there could be no question as to its repeated occurrence, whatever may be the precise interpretation. The fish was lighted up dully and in the indirect manner for which as yet I have no explanation. It swam slowly about and when it encountered another fish or my finger, it turned with a quick flick of the tail, emitting a very brilliant flash from its two precaudal photophores, and then vanished completely. This quenching was achieved in one of two diverse ways. If the fish was swimming upside down, as it often does, it turned over after the caudal flash and exposed the unlighted dorsal area, or it sometimes actually turned out every light, from head to tail.

The actions of various individuals differed widely. One which was brought in some time after our first specimens had begun to die down, swam continually on its back and glowed dully from every photophore. Rarely it blackened, and twice I saw sets of four and of six photophores respectively, lit as individual units. The brightest light on the entire body was the most dorsal of the pre-pectoral set.

When first caught, even when dipped gently in a net from the companionway and dropped at once into a bucket of water, the immediate instinct of the fish is to descend. It swims in small circles, making constant nose dives and bumping its head against the bottom.

Two other *Lampanyctus* lighted up as a whole, but the general effect was always of separate lights, the photophores not being

so near together as in *M. coccoi* and the silver scales being absent. It is curious that although *coccoi* is so intensely active, its scales are far less deciduous than those of other species. Holding *L. macropterus* by the head resulted in intense general illumination, and even in the air the light lasted a considerable time before being douched. When it went out, the head and tail lights were sustained alone. When a male was held by the head, while the entire under surface was aglow, the dorsal aspect was entirely black except for the median, dorsal, caudal plates.

A few days later several large specimens of this species were watched. In the darkroom they glowed dully, never as brilliantly in general as *M. coccoi.* Their lunate light organs seemed to diminish the glow. They swam upside down, and suddenly one made a rush, seized the other by the jaw and began pushing him about. Both seemed to have the same grip, and the pushing on the part of both kept up until death. The whole affair was of course accidental. Sometime after apparent death, the jaw lights glowed faintly. During life these six lights were the dominant ones, with the exception of the succeeding pair on the isthmus, which occasionally shone with a very powerful glare. When the entire fish was aglow, a hand lens showed every ventral light shining full strength, but to the unaided eye the illumination was indefinite, indirect. In daylight the photophores are bright purple.

Study Material.

A total of 150 specimens was taken, as follows: *Arcturus* Expedition, Station 50 T-5(2); 74 T-1(24); 74 Pt-1(3); 74 Pt-2 (1); 74 T-7(1); 74 T-10 (4); 74 T-11(3); 74 T-15(2); 74 T-16(1); 74 T-21(1); 74 T-22(14); 74 Ot-2(1); 74 Ot-3(1); 74 T-27 (1); 74 T-35(1); 74 T-35(1); 74 T-41(3); 74 T-43(7); 84 T-2(24); 84 T-10(1); 84 T-10(2); 84 T-10(5); 84 T-14(10); 84 Pt-3 (2); 84 Pt-3(14); 86 T-2(2); 86 T-2(1); 86 T-4(2); 86 T-5(3); 86 T-11(3); 87 T-2 (6); 87 T-6(4). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

References and Synonymy.

(Synonymy accepted according to Parr, 1931, p. 28).

Myctophum (*Lampanyctus*) *macropterum:*

Brauer, 1904, pp. 381, 404, fig. 5. (Key and description of type specimen).

Brauer, 1906, p. 249, figs. 166, 167. (22 specimens; ? to 65 mm.; 547 to 1,368 fathoms; Indian Ocean, Bay of Bengal, Ceylon, Cocos, Seychelles Islands, Gulf of Aden, North Africa, (*partim*) and fig. 166, nec. fig. 167).

Pappenheim, 1914, p. 196. (1 specimen; 63 mm.; ? to 1,642 fathoms; south Atlantic).

Lampanyctus macropterus:

Gilbert, 1913, p. 106. (1 specimen; 105 mm.; 703 (?) fathoms; Kagoshima, Japan).

Regan, 1916, p. 140. (1 specimen; 10 mm.; 2 fathoms; New Zealand).

Parr, 1928, pp. 88, 110, fig. 20. (Key to species; synonymy; description; 4 specimens; ? mm.; 7-8,000 feet wire; West Indies).

Parr, 1931, pp. 25, 28, fig. 10. (nec. Parr, 1928, p. 110; key to species; discussion; synonymy).

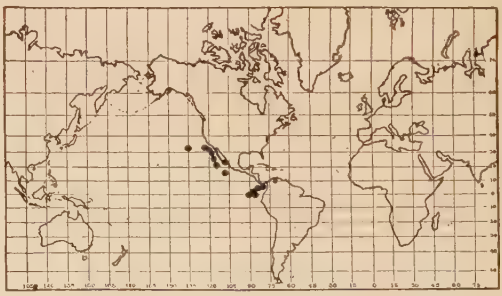
Lampanyctus mexicanus (Gilbert, 1890).

Specimens taken by Eastern Pacific Expeditions: 36 specimens; *Arcturus* Oceanographic Expedition; 255 to 833 fathoms; between 0° 17′ S. and 6° 24′ N. Lat., and between 81° 18′ and 91° 34′ W. Long.; lengths 13.5 to 64 mm.; March 30 to June 9, 1925.

177 specimens: Templeton Crocker Expedition; surface to 500 fathoms; between 23° 25′ and 30° 00′ N. Lat., and 108° 31′ and 116° 27′ W. Long.; lengths 19 to 63 mm.; March 28 to May 23, 1936.

4 specimens; Eastern Pacific (*Zaca*) Expedition; 500 fathoms; between 5° 10′ and 9° 12′ N. Lat., and 78° 42′ and 85° 08′ 30″ W. Long.; lengths 18 to 52 mm.; February 7 to March 26, 1938.

Specimens previously recorded: 143+ specimens; ? to 64.7 mm.; surface to 1,218 fathoms; eastern Pacific, from California at Point Conception south to Ecuador.



Text-fig. 17. Distribution of *Lampanyctus mexicanus.*

Photophore variation: Ten of the 36 fish from the *Arcturus* had asymmetrical counts; 15 were symmetrical, 5-9; and the remaining 11 were about equally divided among the symmetrical combinations of 4-8, 4-9, 4-10, 5-8, 5-10.

The count on 25 fish from the Templeton Crocker group showed that 13 specimens, or 50 per cent., had the 4-9 pattern, with the others varying from 4-8 to 5-9. Three individuals have asymmetrical patterns on the two sides of the body.

Vertical distribution: Lampanyctus mexicanus is a deep water species as the vertical distribution of our catch well shows. 106

fish (59 per cent.) were taken at 300 fathoms; 53 (30 per cent.) at 400; and 21 fish (11 per cent.) from 500 fathoms. Only a single individual was captured in a surface haul.

Sociability: Schooling was more evident than in any other species encountered. About 60 per cent. of the entire catch, or 105 fish, was taken in a single net, but this is only part of the truth. The same school evidently extended throughout 200 vertical fathoms, for on April 17, three nets on the same wire, drawn from 3.45 to 5.00 P.M., at 300, 400 and 500 fathoms contained 105, 25 and 19 fish respectively, or four-fifths of all of this species taken on all three expeditions. The remaining fish were distributed as follows: one net (13 fish), one net (10 fish), and nine nets (1 fish each).

Study Material.

A total of 217 specimens was taken, as follows: *Arcturus* Expedition, Station 26 Pt-1(1); 39 T-4(1); 59 Pt-2(1); 66 Pt-1 (1); 74 Pt-1(1); 74 Pt-3(3); 74 Ot-3(1); 74 Ot-4(1); 84 T-2(5); 84 Pt-1(7); 84 T-8 (4); 84 T-14(8); 84 Pt-3(2). Templeton Crocker Expedition, Station 130 T-1(13); 139 T-2 and T-3 and T-4(10); 148 T-2 (105); 148 T-3(25); 148 T-4(19); 148 T-8 (1); 158 T-3(1); 158 T-4(1); 159 T-1(1); 174 L-1(1). Eastern Pacific (*Zaca*) Expedition, Station 210 T-6(1); 210 T-10(1); 227 T-1(1); 230 T-1(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 135).

Myctophum mexicanum:

Gilbert, 1890, p. 51. (6 specimens, including type; ? to 50 mm.; 306 to 857 fathoms; Gulf of California).

Scopelus mexicanus:

Lütken, 1892, p. 266. (Name listed).

Nannobrachium mexicanum:

Goode & Bean, 1895, p. 512. (Name listed).

Myctophum oculeum:

Garman, 1899, p. 260, pl. 56, fig. 2. (? specimens; ? mm.; surface to 1,218 fathoms; off Pacific coast lower California, south to Ecuador).

Myctophum (Lampanyctus) mexicanum:

Brauer, 1904, p. 396. (Key to species).

Myctophum (Lampanyctus) oculeum:

Brauer, 1906, p. 167. (Key to species).

Lampanyctus oculeus:

Parr, 1928, p. 85. (Key and synonymy).

Parr, 1934, p. 46. (Synonymizes with *L. mexicanus*).

Lampanyctus mexicanus:

Parr, 1928, p. 84. (Key and synonymy).

Parr, 1929, p. 15, fig. 6. (Key and further description of type).

Parr, 1931, p. 30, fig. 12. (23 specimens; ? to 60 mm.; ? to 286 fathoms; eastern Pacific coast of Mexico).

Bolin, 1939, pp. 93, 135, fig. 21. (Key; synonymy; description; 114 specimens; 15.5 to 64.7 mm.; ? fathoms; from Point Conception, California south to Gulf of California. These include 2 co-types and 4 of Garman's *M. oculeum*).

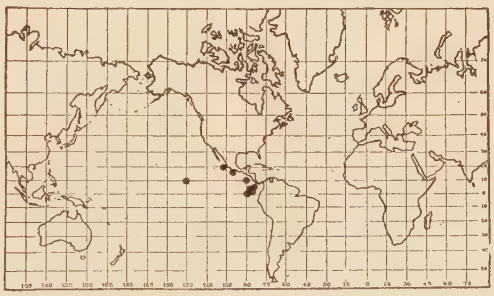
Lampanyctus omostigma Gilbert, 1908.

Specimens taken by Eastern Pacific Expeditions: 246 specimens; *Arcturus* Oceanographic Expedition: surface to 1,200 fathoms; between 2° 00′ S. and 6° 27′ N. Lat., and 83° 33′ and 91° 53′ W. Long.; lengths 12 to 68 mm.; between April 22 and June 13, 1925.

94 specimens; Eastern Pacific (*Zaca*) Expedition: 300 to 500 fathoms; between 5° 10′ and 17° 45′ N. Lat., and 78° 42′71″ and 103° 05′ W. Long.; lengths 13 to 96 mm.; between Nov. 23, 1937 and March 26, 1938.

Specimens previously recorded: 30 specimens; ? to 62 to ? mm.; surface to 200 fathoms; mid-Pacific near Marquesas Islands and eastern Pacific from Mexico to Galápagos. Our collection establishes the species as occurring nearly 800 miles south of the earlier known range.

After careful examination of our specimens we fail to find sufficient consistent variation to differentiate these eastern Pacific fish as *Lampanyctus omostigma parvicauda* (Parr, 1931, p. 26, fig. 9).



Text-fig. 18. Distribution of *Lampanyctus omostigma.*

Photophore variation: The range in number of anal photophores is 4-8 and 6-10, with the dominant nodes at 5-8 and 5-9, appearing on 34 specimens each, totaling 68 specimens or more than 41 per cent. of the 163 specimens examined. Forty-four specimens or 27 per cent. were asymmetrical in the bilateral count.

Breeding: One female (Cat. No. 6057) 59 mm. in length was in full breeding condition. This fish was taken at the surface on June 1; the ovaries were 13 mm. in length, and the total number of enlarged eggs about 2,700.

Vertical distribution: This is one of the deeper-living species of the family. About one-third of the entire catch came from a depth of 500 fathoms, with numbers grading sharply down above and below this depth. The data is as follows: surface (96 fish), 100 fathoms (4 fish), 300 fathoms (18 fish), 400 fathoms (12 fish), 500 fathoms (130 fish), 600 fathoms (62 fish), 700 fathoms (11 fish), 800 fathoms and deeper (7 fish).

Sociability: The only real hint of schooling is in one surface net which captured 90 fish within an hour, 8.30 to 9.30 P. M. Of the remaining 54 nets, 28 contained only one or two fish each, while six nets took numbers ranging from 10 to 28 individuals.

Luminescence and viability: Three large fish were taken into the darkroom as soon as caught. They showed at first no general luminescence but a multitude of bright sparks. These increased upon agitation of the water and seemed to come from every photophore on the body. Only twice thereafter, within a space of five minutes, did I see very briefly the dull, indirect glow so characteristic of a species such as *Myctophum affine.* The light was clear white and brightly illumined the entire dish and all the surrounding plankton. Usually the fish lay on their sides, and there was little light visible from beneath their bodies. It vanished abruptly with death.

Study Material.

A total of 340 specimens was taken, as follows: *Arcturus* Expedition, Station 50 Pt-1(1); 50 Pt-1(1); 53 T-1(3); 56 T-1(6); 59 T-2(4); 59 Pt-1(7); 59 Pt-1(7); 61 T-4(2); 65 Ot-1 and T-3 and T-4(90); 66 T-2(24); 66 Pt-1 (20); 66 Pt-1(1); 66 T-2 (1); 66 T-2 (6); 66 T-3(16); 67 T-1(1); 68 Pt-1(2); 68 Pt-1(5); 74 Pt-3(3); 74 T-22(3); 74 T-26(1); 74 T-42(1); 74 T-69(2); 84 T-10(2); 84 T-14(1); 84 Pt-1(10); 84 Pt-3(1); 84 Pt-4(2); 84 T-19(1); 84 T-20(3); 86 T-4(2); 86 T-7(1); 86 T-8(3); 86 Pt-1(3); 87 T-3(4) 87 Pt-1(6). Eastern Pacific (*Zaca*) Epedition, Station 185 T-1(1); 210 T-1(6); 210 T-2(2); 210 T-3(5); 210 T-6(3); 210 T-6 (28); 210 T-7(1); 210 T-7 (16); 210 T-8(2); 210 T-10(8); 210 T-10 (1); 219 T-1(9); 219 T-2(2); 219 T-2(1); 225 T-1(2); 225 T-1(1); 227 T-1(3); 228T-1(2); 230 T-1(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII. pp. 6-23 (*Arcturus*); Vol. XXIII, pp. 287-298 (*Zaca*).

References and Synonymy.

Lampanyctus omostigma:

Gilbert, 1908, p. 232, pl. 5. (Type specimen; 62 mm.; also co-type same length; surface; 1,000 miles north of Marquesas).

Jordan & Jordan, 1922, p. 12. (Name listed).

Fowler, 1928, p. 68. (Description, synonymy).

Parr, 1928, p. 88. (Key to species).

Parr, 1929, p. 22. (Reexamination of type).

Parr, 1931, pp. 25, 28, fig. 9. (Key to species).

Lampanyctus omostigma parvicauda:

Parr, 1931, p. 25, fig. 9. (28 specimens, including type and co-type; ? mm.; 100 to 200? fathoms; off western coast Mexico and Nicaragua).

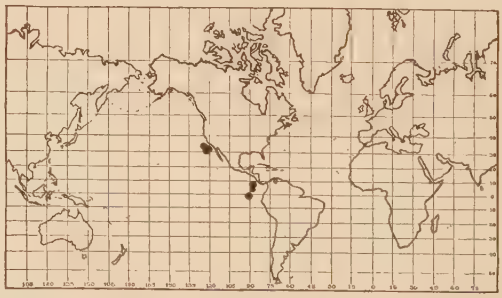
Lampanyctus ritteri Gilbert, 1915.

Specimens taken by Eastern Pacific Expeditions: 19 specimens; *Arcturus* Oceanographic Expedition; 400 to 800 fathoms; between 0° 17′ S. and 6° 27′ N. Lat., and 85° 00′ and 91° 47′ W. Long.; lengths 15 to 68 mm.; between May 13 and June 12, 1925.

1 specimen; Eastern Pacific (*Zaca*) Expedition; 500 fathoms; 8° 03′ N. Lat., and 83° 12′ W. Long., length 45 mm.; March 10, 1938.

Specimens previously recorded: 27 specimens; ? to 142 mm.; 350 (?) to 599 fathoms off coast of southern California.

The present paper extends the range of this species about 1,920 miles south to the Galápagos.



Text-fig. 19. Distribution of *Lampanyctus ritteri.*

Photophore count and variation: There is considerable variation in the count of anal photophores given by other authors in earlier keys. Gilbert, who described this species, gives 7-8; Bolin 6-8 and 8-9; Parr 8 and 7-8.

Our single (*Zaca*) specimen shows 5-7 on left side, 5-8 on right. The majority of our *Arcturus* fish are slightly mutilated, but the extremes of the countable series are 5-8 and 9-10.

Food: The stomach of one fish contained

two euphausids and one copepod, while another had indulged in two copepods and one euphausid.

Study Material.

A total of 20 specimens was taken, as follows: *Arcturus* Expedition, Station 66 Pt-1(2); 68 T-5(3); 68 Pt-1(3); 74 Pt-1 (1); 74 Ot-2(1); 84 Pt-1(1); 84 Pt-3(6); 84 T-8(1); 86 T-10(1). Eastern Pacific (*Zaca*) Expedition Station 219 T-2(1). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXIII, pp. 287-298 (*Zaca*).

References.

Lympanayctus ritteri:

Gilbert, 1915, p. 318, pl. 15, fig. 3. (5 specimens, including type; ? to 142 mm. total length; 350 to 599 fathoms; Monterey Bay, California).

Parr, 1928, p. 89, fig. 24. (Key to species).

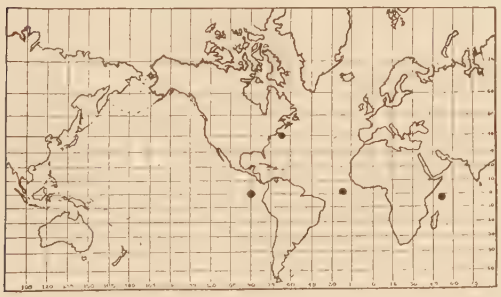
Parr, 1929, p. 23. (Further description).

Bolin, 1939, p. 141, fig. 24. (24 specimens; including 2 co-types; 19.9 to 100.0 mm.; ? fathoms; vicinity San Clemente Island to Point Reyes, California).

Lampanyctus tenuiforme (Brauer, 1906).

Specimens taken by Eastern Pacific Expeditions: 5 specimens; *Arcturus* Oceanographic Expedition; 500 to 700 fathoms; between 0° 17′ S. Lat. and 0° 00′ equator, and 91° 34′ and 91° 53′ W. Long.; lengths 24 to 25.5 mm.; June 9 to 13, 1925.

Specimens previously recorded: 4 specimens; 16 to 24 mm.; (?) 1,093 to 1,642 fathoms; Hudson Gorge, northwest Atlantic, south Atlantic, Indian Ocean. Our specimens are the first recorded from the eastern Pacific.



Text-fig. 20. Distribution of *Lampanyctus tenuiforme.*

Photophore variation: Analysis of our five specimens shows the following arrangements: 6-9, 6-9, 6-10, 7-8, and one with the asymmetrical combination of 6-9, 6-10.

No sex glands are present in our individuals.

Study Material.

A total of 5 specimens was taken as follows: *Arcturus* Expedition, Station 84 Pt-3(3); 84 T-14(1); 87 Pt-1(1). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23.

References and Synonymy.

(Synonymy accepted according to Parr, 1928, p. 83).

Myctophum (Lampanyctus) tenuiforme:

Brauer, 1906, p. 243, fig. 160. (Original description; 1 specimen; 21 mm.; 1,093 fathoms; Indian Ocean).

Pappenheim, 1914, p. 197. (1 specimen; 16 mm.; ? to 1,642 fathoms; south Atlantic).

Lampanyctus tenuiforme:

Parr, 1928, p. 83. (Key to species; synonymy).

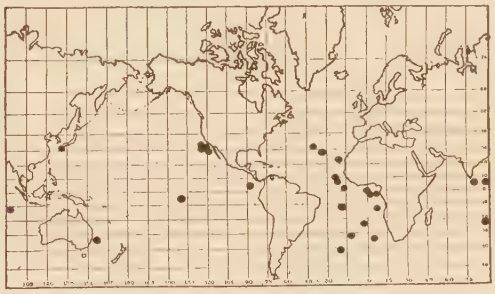
Parr, 1931, p. 28. (Reference).

Beebe, 1929, p. 16. (2 specimens; 18 and 24 mm.; 600 fathoms; Hudson Gorge, northwest Atlantic).

Lampanyctus townsendi (Eigenmann & Eigenmann, 1889).

Specimens taken by Eastern Pacific Expeditions: 1 specimen; *Arcturus* Oceanographic Expedition; 600 fathoms; 6° 24′ N. Lat., and 85° 00′ W. Long.; length 35 mm.; June 9, 1925.

Specimens previously recorded: 43 specimens, ? to 78.5 mm.; surface to 1,367 fathoms; north and south Atlantic Ocean, Indian Ocean, Australia, Japan, mid- and eastern Pacific from southern California to Panama Bay. Our specimen extends the range southward about 2,000 miles.



Text-fig. 21. Distribution of *Lampanyctus townsendi.*

General data: Our specimen is badly damaged and torn but all the characters are distinct. It is Cat. No. 5687b, and was taken at Station 66 Pt-1, 130 miles northeast of Cocos Island.

Study Material.

One specimen was taken, as follows: *Arcturus* Expedition, Station 66 Pt-1(1). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23.

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 147).

Myctophum townsendi:

Eigenmann & Eigenmann, 1889, p. 125. (Original description; type specimen; ? mm.; 45 fathoms; Cortez Bay, San Diego, California).

Scopelus (Nyctophus) warmingii:

Lütken, 1892, p. 259, fig. 19. (Original description; type specimen; 63 mm.; mid-Atlantic).

Scopelus townsendi:

Lütken, 1892, p. 267. (This refers to *M. californiense*).

Lampanyctus warmingii:

Goode & Bean, 1895, p. 80. (Description).

Lampanyctus townsendi:

Jordan & Evermann, 1896, p. 558. (Description).

Gilbert, 1908, p. 230, pl. IV. (1 specimen; 26 mm.; ? to 300 fathoms; Marquesas).

Gilbert, 1913, p. 98. (Key to species; description; 5 specimens; ? to 60 mm.; surface to 850 fathoms; southern Japan).

McCulloch, 1923, p. 115. (1 specimen; 65 mm.; on beach, Lord Howe Island, Australia).

Fowler, 1928, p. 68. (References).

Parr, 1928, p. 79. (Key to species; synonymy).

Parr, 1929, p. 13. (Considers *M. warmingii* after examination of type).

Norman, 1930, p. 327. (14 specimens; 17 to 67 mm.; surface to 1,094 fathoms; north and south Atlantic).

Matsubara, 1938, p. 56, fig. 11. (1 specimen; 78.5 mm.; ? fathoms; Japan).

Bolin, 1939, pp. 93, 147, fig. 28. (Key to species; description; 7 specimens; 17.4 to 57.1 mm.; ? fathoms; coast of California, Japan).

Myctophum (Lampanyctus) warmingii:

Brauer, 1906, p. 229. (Key to species; description; 7 specimens; ? to 21 mm.; surface to 1,367 fathoms; Gulf of Guinea, Indian Ocean, Bay of Bengal, south of Japan).

Pappenheim, 1914, p. 195. (5 specimens; 19 to 36 mm.; ? to 3,000 metres wire; mid- and south Atlantic).

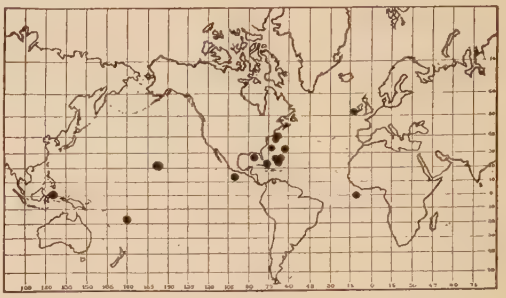
Myctophum (Lampanyctus) townsendi:

Brauer, 1906, p. 167. (Key to species).

Diaphus dumerili (Bleeker, 1856).

Specimens taken by Eastern Pacific Expeditions: 3 specimens; Eastern Pacific (*Zaca*) Expedition; surface; at 16° 30′ N. Lat., and 99° 13′ W. Long.; lengths 53, 54 and 64 mm.; Nov. 29, 1937.

Specimens previously recorded: 65 specimens; ? to 95 mm.; surface to (?) 800 fathoms; northwest Atlantic, Bermuda, Bahamas, West Indies, Gulf of Mexico, southwest of Ireland, south Atlantic, Fiji Islands, Hawaii and Celebes.



Text-fig. 22. Distribution of *Diaphus dumerili.*

Photophore variation: Two fish showed the combination of 7-5, while the third presented the asymmetrical formula of 7-6, 6-6.

Study Material.

A total of 3 specimens was taken, as follows: Eastern Pacific (*Zaca*) Expedition, Station 190 L(3). For detailed trawling data, refer to *Zoologica,* Vol. XXIII, pp. 287-298.

References and Synonymy.

(Synonymy accepted according to Parr, 1928, p. 126).

Scopelus dumerilii:

Bleeker, 1856, vol. 1, p. 66. (Description and type locality, Manado, Celebes).

Günther, 1864, vol. 22, p. 410. (Brief description).

Günther, 1887, p. 198. (Description; 1 specimen; 76 mm.; 315 fathoms; Fiji Islands).

Scopelus schmitzi:

Johnson, 1890, p. ? (Reference not seen; synonymized by Tåning, 1928, p. 58).

Myctophum nocturnum:

Poey, 1860, p. 416. (Brief description; 1 specimen; 95 mm.; ? fathoms; ? locality).

Myctophum (Nyctophus) lacerta:

Brauer, 1904, p. 392. (Key to species).

Collettia nocturna:

Jordan & Evermann, 1896, p. 567. (Description).

Diaphus nocturnus:

Gilbert, 1906, p. 255. (Detailed description of types and co-types).

Myctophum dumerili:

Weber & Beaufort, 1913, p. 670. (Brief reference).

Lampanyctus lacerta:

Goode & Bean, 1895, p. 81, fig. 89. (Type description; 3 specimens; ? to 57 mm.; surface to 671 fathoms; northwest Atlantic, Gulf of Mexico).

Jordan & Evermann, 1896, p. 560. (Brief description).

Breder, 1927, p. 17. (Brief description; ? specimens; 50 mm.; ? fathoms; West Indies).

Diaphus dumerili nocturnus:

Tåning, 1928, p. 58. (Key to species).

Diaphus dumerili:

Fowler, 1928, p. 68. (Brief description; synonymy; 1 specimen; ? mm.; ? fathoms; Hawaii).

Parr, 1928, pp. 115, 126-130, fig. 23. (Key to species; synonymy; detailed description and discussion; 47 specimens; ? to 73 mm.; surface to 800 fathoms; San Salvador and Acklin Islands, in the Bahamas).

Parr, 1929, pp. 29, 31. (Key to species; synonymy).

Parr, 1934, p. 48. (Synonymy).

Norman, 1929, p. 511. (1 specimen; 53 mm.; ? fathoms; off southwest Ireland).

Norman, 1930, p. 331. (1 specimen; 47 mm.; 54 to 108 fathoms; south Atlantic).

Borodin, 1931, p. 76. (? specimens; ? mm.; ? fathoms; near Bermuda).

Fraser-Brunner, 1935, p. 319. (Name listed).

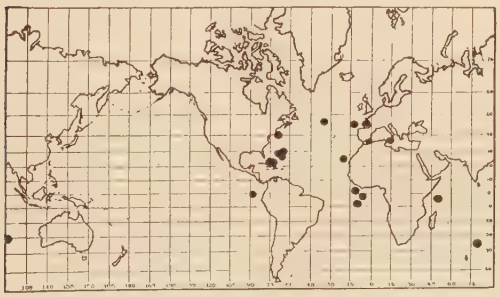
Beebe, 1929, p. 15. (2 specimens; ? mm.; ? fathoms; Hudson Gorge, northwest Atlantic).

Beebe, 1937, p. 204. (Preliminary list; 7 specimens; 54 to 66 mm.; surface; Bermuda).

Diaphus gemellari (Cocco, 1838).

Specimens taken by Eastern Pacific Expeditions: 1 specimen; *Arcturus* Oceanographic Expedition; 700 fathoms; between 0° 40′ N. Lat., and 88° 51′ W. Long.; length 33 mm.; April 3, 1925.

Specimens previously recorded: 61 specimens; ? to 86 mm.; surface to 1,000 fathoms; northwest Atlantic, Bermuda, Bahamas, West Indies, Canary Islands, Mediterranean, Indian Ocean.



TEXT-FIG. 23. Distribution of *Diaphus gemellari.*

Photophore count: Our specimen shows 5-6, 5-6.

STUDY MATERIAL.

One specimen was taken as follows: *Arcturus* Expedition, Station 33 Pt-1(1). For detailed trawling data, refer to *Zoologica,* Vol. VIII, pp. 6-23.

REFERENCES AND SYNONYMY.

(Synonymy accepted according to Parr, 1928, p. 123).

Nyctophus gemellarii:

Cocco, 1838, p. ? (Reference not seen).

Scopelus gemellarii:

Cuvier & Valenciennes, 1828-49, p. 445. (Brief description).

Günther, 1864, V. 22, p. 415. (Description).

Canestrini, 1870, p. ? (Reference not seen).

Doderlein, 1878-79, p. 54. (Name listed).

Giglioli, 1880, p. ? (Reference not seen).

Vaillant, 1888, p. 117. (Description; 6 specimens; ? mm.; 550 to 1,200 fathoms; Canary Islands, Messina, coast of Morocco).

Raffaele, 1889, p. 183, fig. 8. (Brief description).

Carus, 1889-93, p. 564. (Description).

Scopelus uraeoclampus:

Facciola, 1882-83, p. 50. (Description of type; Messina).

Scopelus (Nyctophus) gemellarii:

Lütken, 1892b, p. 260. (Description).

Myctophum gemellarii:

Bonaparte, 1832-41, V. 3, Fasc. 27, fig. 2. (Detailed description).

Sanzo, 1918a, p. 9. (Description; 8 specimens; 3 to 17 mm.; ? fathoms; Mediterranean).

Myctophum (Nyctophus) gemellarii:

Brauer, 1904, p. 393. (Key to species).

Lampanyctus gemellarii:

Goode & Bean, 1895, p. 80. (Description and synonymy).

Myctophum (Diaphus) gemellari:

Brauer, 1906, pp. 164, 212, figs. 130, 131. (Description; key to species; synonymy; 5 specimens; 12 to 18 mm.; ? fathoms; Messina).

Fage, 1910, p. 13, pl. 1, fig. 7. (Description; 1 specimen; 32 mm.; 500 fathoms; Mediterranean).

Zugmayer, 1911b, p. 29. (Description; synonymy; 1 specimen; 30 mm.; ? fathoms; Mediterranean, Atlantic and Indian Ocean).

Diaphus gemellari:

Tåning, 1918, p. 73. (Description; development; 78 specimens; 5 to 24 mm.; surface to 55 fathoms; Mediterranean).

Tåning, 1928, p. 58. (Key to species).

Parr, 1928, pp. 115, 123-125, figs. 21, 22. (Key to species; synonymy; detailed description; 5 specimens; ? to 45 mm.; 5 to 8,000 feet wire; Bahamas, Bermuda).

Parr, 1929, p. 29. (Key to species).

Parr, 1934, p. 64. (Description; 2 specimens; 37 and 67 mm.; 600 fathoms; north Atlantic).

LeGendre, 1934, p. 340. (Key to species; 2 specimens 1 male, 1 female; 83 and 86 mm.; ? fathoms; Gulf of Gascony).

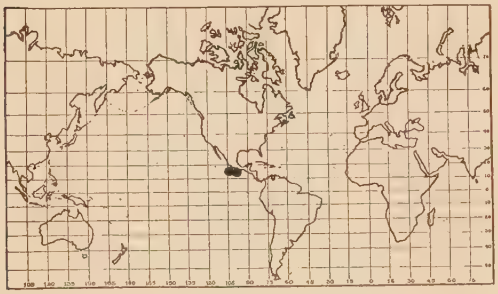
Beebe, 1929, p. 15. (3 specimens; ? mm.; ? fathoms; Hudson Gorge, north Atlantic).

Beebe, 1937, p. 204. (Preliminary list; 27 specimens; 10 to 28 mm.; 300 to 1,000 fathoms; Bermuda).

Diaphus pacificus (Parr, 1931).

Specimens taken by Eastern Pacific Expeditions: 19 specimens; Eastern Pacific (*Zaca*) Expedition: 300 to 400 fathoms; at 17° 45′ N. Lat., and 103° 05′ W. Long.; lengths 24 to 30 mm.; November 23, 1937.

Specimens previously recorded: 1 specimen; 28 mm.; 625 fathoms cable; eastern Pacific coast of Mexico.



TEXT-FIG. 24. Distribution of *Diaphus pacificus*.

Photophore count and variation: In general 5-4 on both left and right side; several were 4-4 on both sides, and one was 5-3. Asymmetrical combinations were 5-4 and 4-4, 4-5 and 5-4 and a third showed 5-3, and 4-5.

STUDY MATERIAL.

A total of 19 specimens was taken, as follows: Eastern Pacific (*Zaca*) Expedition, Station 185 T-1 (13), 185 T-2 (6). For detailed trawling data, refer to *Zoologica*, Vol. XXIII, pp. 287-298.

REFERENCES AND SYNONYMY.

Diaphus pacificus:

Parr, 1931, p. 34, fig. 14. (Description of type specimen; 28 mm.; 625 fathoms cable; eastern Pacific, off coast of Mexico.

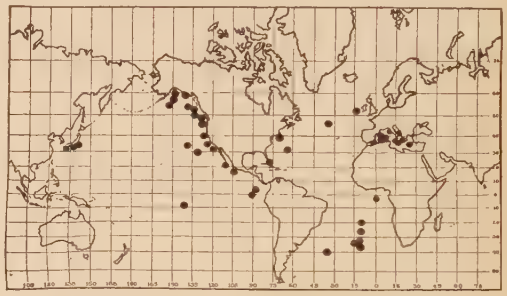
Diaphus rafinesquii (Cocco, 1838).

Specimens taken by Eastern Pacific Expeditions: 19 specimens; *Arcturus* Oceanographic Expedition; 300 to 1,000 fathoms; between 0° 17′ S. and 4° 50′ N. Lat., and 86° 43′ and 91° 53′ W. Long.; lengths 11 to 39 mm.; between May 1 and June 13, 1925.

4 specimens; Templeton Crocker Expedition; 400 to 500 fathoms; at 23° 25′ N. Lat., and 108° 31′ W. Long.; lengths 15 to 27 mm.; April 29, 1936.

1 specimen; Eastern Pacific (*Zaca*) Expedition; 500 fathoms; at 17° 45′ N. Lat., and 103° 05′ W. Long.; Nov. 23, 1937.

Specimens previously recorded: 1,032 specimens; ? to 90 mm.; surface to 1,000 fathoms; north and south Atlantic; Mediterranean, Japan, mid-Pacific, eastern Pacific from Sitka, Alaska down to San Diego, California.



TEXT-FIG. 25. Distribution of *Diaphus rafinesquii*.

Photophore variation: There were five symmetrical combinations in 22 specimens; one was 4-4; eleven were 5-4; two were 5-3; three were 6-3; and five were 6-4. Two fish had the asymmetrical combinations of 4-5, 5-4, and 5-4, 4-4. One of these asymmetrical specimens, (Cat. No. 5571) had the characterestics of *D. holti* on one side.

Vertical distribution: If anything of value can be deduced from the vertical distribution of 24 fish, it is that almost half were taken at 500 fathoms. The exact data is: 300 fathoms (2 fish), 400 (7), 500 (11), 600 (1), 700 (2) and 1,000 fathoms (1 fish).

Sociability: Nothing definite. Eight nets contained one fish each, five nets two, and one net six fish.

STUDY MATERIAL.

A total of 24 specimens was taken, as follows: *Arcturus* Expedition, Station 59 T-3(2); 74 T-78(1); 84 T-20(2); 86 T-1 (1); 86 T-2(6); 86 T-7(1); 86 T-9(1); 86 T-11(1); 87 T-2(1); 87 T-3(2); 87 T-6(1). Templeton Crocker Expedition, Station 158 T-3(2); 158 T-4(2). Eastern Pacific (*Zaca*) Expedition, Station 185 T-3(1). For detailed trawling data, refer to *Zoologica*, Vol. VIII, pp. 6-23 (*Arcturus*); Vol. XXII, pp. 37-46 (Templeton Crocker); Vol. XXIII. pp. 287-298 (*Zaca*).

References and Synonymy.

(Synonymy accepted according to Bolin, 1939, p. 125).

Nyctophus rafinesquii:

Cocco, 1838, p. 20, pl. 3, fig. 7. (Original description; reference not seen).

Myctophum rafinesquei:

Bonaparte, 1832-1841, V. 3, Fasc. 27, fig. 2. (Description).

Sanzo, 1918a, p. 5. (Discussion).

Scopelus rafinesquii:

Cuvier & Valenciennes, 1828-1849, vol. 22, pp. 330, 444. (Brief description).

Günther, 1864, vol. 22, p. 410. (Description of Mediterranean fish).

Giglioli, 1880, p. ? (Reference not seen).

Doderlein, 1878-79, p. 54. (Name listed).

Canestrini, 1870, p. 125. (Reference not seen).

Leydig, 1881, p. ? (Reference not seen).

Raffaele, 1889, p. 183. (Brief description; 13 specimens; ? mm.; ? fathoms; Messina).

Carus, 1889-1893, p. 564. (Description).

Moreau, 1891, p. 98. (Detailed description and synonymy).

Holt & Byrne, 1910, p. 22, fig. 6. (Description; 1 specimen; 75 mm.; 730 fathoms; southwest coast of Ireland).

Scopelus rafinesque:

Weill, 1926, p. 472. (Brief discussion of luminosity).

Scopelus (Nyctophus) rafinesquii:

Lütken, 1892, p. 258, fig. 17. (Description; 3 specimens; 43, 64 and 90 mm.; ? fathoms; ? locality).

Scopelus protoculus:

Lütken, 1892, p. 266. (Reference).

Myctophum protoculus:

Gilbert, 1890, p. 52. (Description of type; 3 specimens; ? mm.; 584 fathoms; off Cape Johnson, Washington).

Parr, 1929, p. 32. (Discussion of synonymy).

Myctophum (Nyctophus) rafinesquii:

Brauer, 1904, p. 393. (Key to species; synonymy).

Myctophum (Nyctophus) theta:

Brauer, 1904, p. 393. (Key to species).

Myctophum (Diaphus) theta:

Brauer, 1906, p. 165. (Key to species).

Diaphus theta:

Eigenmann & Eigenmann, 1890, p. 4. (11 specimens from the mouths of rock cod, Point Loma, California).

Evermann & Goldsborough, 1906, p. 271. (1 specimen; 57 mm.; 922 fathoms; Sitka, Alaska).

Diaphus nanus:

Gilbert, 1908, p. 224, pl. 1. (Type description; 1 specimen; 17 mm.; surface to 300 fathoms; Marquesas).

Gilbert, 1913, p. 87. (Description; ? specimens; ? 45 mm.; ? 300 fathoms; Japan).

Diaphus holti:

Tåning, 1918, pp. 88-92, figs. 35, 36. (Detailed description; distribution map; 638 specimens; 275 to 550 fathoms; near Messina, Mediterranean and Bay of Cadiz).

Diaphus mollis:

Tåning, 1928, p. 60. (Preliminary type description; key to species).

Collettia rafinesquei:

Goode & Bean, 1896, p. 88, pl. 26, fig. 100. (Description; synonymy; 3 specimens; ? to 77 mm.; northwest Atlantic).

Jordan & Evermann, 1896, p. 567. (Description).

Myctophum (Diaphus) rafinesquei:

Brauer, 1906, pp. 165, 223, figs. 144, 145. (Key to species; description; synonymy; 25 specimens; ? to 66 mm.; ? fathoms; Messina).

Zugmayer, 1911, p. 32. (Synonymy; 2 specimens; ? to 30 mm.; ? fathoms; Mediterranean).

Diaphus rafinesquii:

Tåning, 1918, pp. 83-87, figs. 33, 34. (Detailed description; distribution map; 123 specimens; surface to 1,093 fathoms; Mediterranean).

Tåning, 1928, p. 60. (Key to species).

Parr, 1928, pp. 119, 131-135, figs. 25, 26. (Key to species; synonymy; detailed discussion; 4 specimens; 38 to 46 mm.; 7 to 10,000 feet wire; Bahamas, Bermuda).

Parr, 1929, p. 32, fig. 16. (Key to species; synonymy; detailed discussion and description).

Parr, 1934, pp. 51, 65. (Reference to type in poor condition; also 1 specimen; ? mm.; 600 fathoms; mid-north Atlantic).

Norman, 1930, p. 334. (References; brief discussion; 27 specimens; 16 to 70 mm.; ? fathoms; south Atlantic).

LeGendre, 1934, p. 341. (Key to species).

Beebe, 1937, p. 203. (Preliminary list; 134 specimens; 9 to 70 mm.; 400 to 1,000 fathoms; Bermuda).

Bolin, 1939, pp. 93, 125, fig. 18. (Key to species; synonymy; detailed description; 23 specimens, including 4 co-types 11 to 65.6 mm.; ? fathoms; from mid-Washington to southern California, Japan, Messina).

Chapman, 1940, p. 33. (Description; 22 specimens; 45 to 73 mm.; ? to 850 metres wire; eastern Pacific between Alaska and British Columbia).

Bibliography.

Alaejos, Sanz. L.

1919. Datos para la fauna ictiologica de las costas de Santander. *Bol. Pescas*, Madrid, 1919.

Alcock, A. W.

1890. Natural history notes from H. M. Indian Marine Survey Steamer "Investigator," No. 18. On the bathybial fishes of the Arabian Sea obtained during the season 1889-1890. *Ann. Mag. Nat. Hist.*, Ser. 6, Vol. 6, 1890.

1896. Natural history notes from H. M. Indian Marine Survey Steamer "Investigator," Ser. II, No. 23. A supplementary list of the marine fishes of India, with descriptions of 2 new genera and 8 new species. *Ibid.*, Vol. 65, Pt. 3, 1896.

Barnard, H. K.

1925. A monograph of the marine fishes of South Africa, Pt. 1. *Ann. South African Mus.*, Vol. 21, 1925.

Beebe, William.

1929. Deep-sea fish of the Hudson Gorge. *Zoologica*, Vol. XII, No. 1, 1929.

1937. Preliminary list of Bermuda deep-sea fish. Based on collections from fifteen hundred metre-net hauls, made in an eight-mile circle south of Nonsuch Island, Bermuda. *Zoologica*, Vol. XXII, No. 27.

Bleeker, P.

1856. Beschrijvingen van nieuwe of wenig bekende vischsoorten van Menado en Makassar. *Act. Soc. Sci. Indo-Neerl.*, Vol. 1, 1856.

1862-77. Atlas ichthyologique des Indes Orientales Neerlandaises. Amsterdam, 1862-77.

Bolin, Rolf L.

1939. A Review of the Myctophid Fishes of the Pacific Coast of the United States and of Lower California. *Stanford Ichthyological Bulletin*, Vol. 1, No. 4.

Bonaparte, C. L.

1832-41. Iconografia della fauna italica, Tomo. III. Pesci. Roma, 1832-41.

Borodin, Nicholas.

1931. Atlantic Deep-Sea Fishes. *Bull. Museum Comp. Zool.*, Harvard College, Vol. LXXII, No. 3. Cambridge, August, 1931.

Brauer, A.

1904. Diagnosen von neuen Tiefseefischen, welche von der Valdivia Expedition gesammelt sind. Die Gattung Myctophum. *Zool. Anz.*, Vol. 28, 1904.

Brauer, A.

1906. Die Tiefsee-Fische, I, Systematischer Teil (II, Anatomischer Teil, 1908). Wiss. Ergebnisse Deutsch. Tiefsee-Exp. Valdivia, Vol. 15, Lief. 1. Jena, 1906.

Breder, C. M.

1927. Fishes. Scientific results of the first oceanographic expedition of the "Pawnee," 1925. *Bull. Bingham Oceanographic Coll.*, Vol. 1, Art. 1, 1927.

Canestrini, G.

1870. Pesci d'Italia. Cornalia, E.: Fauna d'Italia, Pt. III, Milano, 1870-1874.

Carus, J. V.

1889-1893. Prodromus faunae Mediterraneae, Vol. 2, Vertebrata, 1 class, Pisces. Stuttgart, 1889-1893.

Chapman, W. McL.

1940. Oceanic Fishes from the Northeast Pacific Ocean. *Occasional Papers Brit-Columbia Provincial Museum*, No. 2, May 11, 1940.

Cocco, A.

1829. Su di alcuni nuovi pesci del mare di Messina. *Giorn. Sci. Lett. Arti. Sicil.*, Palermo, 1829.

1838. Su di alcuni Salmonidi del mare di Messina; lettera al Ch. D. Carlo Luciano Bonaparte. *Nuovi. Ann. Sci. Nat. Bologna*, Vol. 2, 1838.

Collet, R.

1880. Den norske Nordhavs-expedition 1876-1878. *Zoologi. Fiske.*, Christiania, 1880.

1880a. Meddelelser om Norges fiske i aarene 1875-1878. *Vidensk. Selsk. Forhandl.*, 1879. Christiania, 1880.

1884. Meddelelser om Norges fiske i aarene 1879-1883. *Nyt. Mag. for Naturv.*, Vol. 29. Christiania, 1884.

1896. Poissons provenant des campagnes du yacht "L'Hirondelle" (1885-88). *Result. Camp. Sci. Monaco*, Vol. 10, 1896.

Costa, O. G.

1844. Pesci della fauna napolitana con illustrazione di specie nuovi, Vol. 1, Napoli, 1844.

Cuvier, G. L. C. F. D., & Valenciennes, A.

1828-49. Histoire naturelle des poissons. Paris, 1828-49.

Doderlein, P.

1878-79. Prospeto metodico delle varie specie di Pesci . . . della Sicilia. *Atti dell'Acad. Sci. Lett. Arti. Palermo*, n. ser., Vol. 6, 1878-79.

Eigenmann, C. H., & Eigenmann, R. S.

1889. Notes from the San Diego Biological Laboratory. The fishes of Cortez Banks. *West Amer. Scientist*, Vol. 6, No. 48. San Diego, 1889.

1890. Additions to the fauna of San Diego. *Proc. Calif. Acad. Sci.*, Ser. II, Vol. 3, Pt. 1. San Francisco, 1891.

Evermann, B. W., & Goldsborough, E. L.

1906. The Fishes of Alaska. *Bull. U. S. Bureau of Fisheries*, Vol. 26.

EVERMANN, B. W. & SEALE, A.
1907. Fishes of the Philippine Islands. *Bull. Bur. Fisheries*, Dept. Comm. Labor, Washington, Vol. 26, 1906 (1907).

FACCIOLA.
1882-83. Pesci nuovi o poco noti dello Stretto di Messina. (Various articles, see *Zool. Record* for 1883). *Fl. Natural. Sicil.*, I-III., Palermo, 1882-1883.

FAGE, L.
1910. Recherches sur les stades pélagiques de quelques Teléostéens. *Ann. L'Inst. Oceanogr.*, Vol. 1, No. 7. Monaco, 1910.

FOWLER, H. W.
1925. New taxonomic names of West African marine fishes. *Amer. Mus. Novitates*, No. 162. New York, 1925.
1928. The fishes of Oceania. *Mem. Bernice P. Bishop Mus.*, 10, 1928.

FRASER-BRUNER, A.
1935. New or Rare Fishes from the Irish Atlantic Slope. *Proc. Roy. Irish Acad.*, B, 42 (9).

GARMAN, S.
1899. The fishes. Report on an exploration by U. S. Fish Comm. Steamer "Albatross," 1891. *Mem. Mus. Comp. Zool.*, Harvard College, Cambridge, Mass., 1899.

GIGLIOLI, E. H.
1880. Elenco dei mammiferi . . . appartenenti alla fauna italiana, e catalogo degli anfibi e dei pesci italiani. Firenze, 1880.

GILBERT, C. H.
1890. Preliminary report on the fish collected by the steamer "Albatross" on the Pacific coast of North America during the year 1889. *Proc. U. S. Nat. Mus.*, Vol. 13, 1890 (1891).
1905. The deep-sea fishes of the Hawaiian Islands. The aquatic resources of the Hawaiian Islands, Pt. II, Sec. 1. *Bull. U. S. Fish Comm.*, Vol. 23, 1903. Washington, 1905.
1906. Certain Scopelids in the collection of the Museum of Comparative Zoology. *Bull. Mus. Comp. Zool.*, Harvard College, Cambridge, Mass., Vol. 46, No. 14, 1906.
1908. The lantern fishes. Rept. Sci. Res. Exp. Trop. Pacific "Albatross," 1899-1900, X. *Mem. Mus. Comp. Zool.*, Harvard College, Cambridge, Mass., Vol. 26, No. 6, 1908.
1911. Notes on lantern fishes from southern seas, collected by J. T. Nichols in 1906. *Bull. Amer. Mus. Nat. Hist.*, Vol. 30, Art. 2, 1911.
1913. The lantern fishes of Japan. *Mem. Carnegie Mus.*, Vol. 6, No. 2, 1913.
1915. Fishes collected by the U. S. Fisheries steamer "Albatross" in 1904. *Proc. U. S. Nat. Mus.*, Vol. 48, 1915.

GILCHRIST, J. D. F.
1908. Description of fifteen new South African fishes. *Mar. Inv. South Africa*, Vol. 4, 1908.

GOODE, G. B. & BEAN, T. H.
1895. Oceanic ichthyology. A treatise on the deep-sea and pelagic fishes of the world. *Special Bull. U. S., Nat. Mus.*, Washington, 1895.

GÜNTHER, A.
1864. Catalogue of the fishes in the collection of the British Museum, London, Vol. V, 5. London, 1864.
1887. Report on the deep-sea fishes. Rept. Sci. Res. "Challenger," Vol. 22, 1887.
1889. Report on the pelagic fishes. *Ibid.*, Vol. 31, 1889.

HOLT, E. W. L., & BYRNE, L. W.
1906. First report on the fishes of the Irish Atlantic slope. Fisheries, Ireland, Sci. Invest. 1905. Append. II, 1906.
1911. Fifth report on the fishes of the Irish Atlantic slope. *Ibid.*, 1910, VI, 1911.

HUTTON, F. W.
1873. Contributions to the ichthyology of New Zealand. *Trans. Proc. New Zealand Inst.*, Vol. 5, 1872. Wellington, 1873.

JOHNSON, J. Y.
1890. On some new species of fishes from Madeira. *Proc. Zool. Soc. London*, 1863.

JORDAN, D. S. & EVERMANN, B. W.
1896. The fishes of North and middle America, Vol. 1. *Bull. U. S. Nat. Mus.*, 1896. Washington, 1896.
1898. The fishes of North and middle America, Vol. III, *Bull. U. S. Nat. Mus.*, 1898. Washington, 1898.
1903. Descriptions of new genera and species of fishes from the Hawaiian Islands. *Bull. U. S.. Fish Comm.*, Vol. 22, 1902. Washington, 1903.

JORDAN, D. S., & JORDAN, E. K.
1922. A list of the fishes of Hawaii, with notes and descriptions of new species. *Mem. Carnegie Mus.*, Vol. 10, No. 1, 1922-1925.

KOEHLER, R.
1896. Resultats scientifique de la campagne du "Caudan" dans le Golf de Gascogne. *Ann. Univ. Lyon*, Paris, Fasc. 26. Paris, 1896.

LEGENDRE, R.
1934. Annales de L'Institut Oceanographique. Tome XIV, Fasc. VI. La Faune Pelagique de L'Atlantique au large du Golfe De Gascogne, Paris, 1934.

LEYDIG, FRA.
1881. Die augenähnlichen Organe der Fische. Bonn, 1881.

LILLJEBORG, W.

1884-91. Sveriges och Norges fiskar. Upsala, 1884-1891.

LÖNNBERG, E.

1905. The fishes of the Swedish South Polar Expedition. *Wiss. Ergeb, Schwed. Südpolar. Exp.*, Vol. 5, Pt. 6, Stockholm, 1905.

LOWE, R. T.

1839. A supplement to a synopsis of the fishes of Madeira. *Proc. Zool. Soc., London*, Vol. 7, 1839.

1849. Supplement to "A synopsis of the fishes of Madeira." *Trans. Zool. Soc. London*, Vol. 3, 1849.

LÜTKEN, C.

1892a. Spolia Atlantica. Scopelini Musei Zoologici Hauniensis. Bidrag til kundskab om det aabne Havs Laxesild eller Scopeliner. Kgl. Danske Vidensk. Selsk. Skrifter, Raekke 6, Bind 7. Copenhagen, 1892.

1892b. Korte bidrag til nordisk Ichthyographi, VIII. Nogle nordiske Laxesild (Scopeliner). *Vidensk. Meddel. Copenhagen*, Ser. 5, Vol. 3, 1891 (1892).

MALM, A. W.

1863. Nya fiskar, kräft-och blöd-djur for Skandinaviens fauna. *Vetensk. Selsk. Handl. Göteborg*, 1863.

MATSUBARA, K.

1938. Studies on the deep-sea fishes of Japan, VII. On some rare or imperfectly known lantern-fishes in Kumano-Nada. *Journ. Imper. Fisheries Inst.*, Tokyo, Vol. 33, figs. 9-12.

MCCULLOCH, A. E.

1923. Fishes from Australia and Lord Howe Island, No. 2. *Rec. Austr. Mus.*, Sydney, 14, 1923.

MOREAU, E.

1881. Histoire naturelle des poissons de la France. Paris, 1881.

1891. Supplement a l'histoire naturelle des poissons de la France. Paris, 1891.

NORMAN, J. R.

1929. Notes on the Myctophid Fishes of the Genera *Diaphus* and *Myctophum* in the British Museum. *Ann. Mag. Nat. Hist.*, Ser. 10, vol. IV, November 1929.

1930. Oceanic fishes and flatfishes collected in 1925-1927. *Discovery* Reports, vol. 2, Cambridge.

PAPPENHEIM, P.

1914. Die Fische der Deutschen Südpolar-Expedition 1901-1903, II. Die Tiefseefische. Deutsche Sudpolar-Exp. 1901-1903, Bd. 15, Zoologie VII. Berlin, 1914.

PARR, A. E.

1928. Deep-sea fishes of the order Iniomi . . . with annotated keys to the Sudidae, Myctophidae, Scopelarchidae, Evermannellidae, Omosudidae, Cetomimidae and Rondeletidae of the world. *Bull. Bingham Oceanogr. Coll.*, New Haven, Vol. 3, art. 3.

1929. Notes on the species of the Myctophine fishes represented by type specimens in the U. S. National Museum. *Proc. U. S. Nat. Mus.*, vol. 76, art. 10.

1931. Deep-sea fishes from off the western coast of North and Central America . . . and a revision of the Macropterus group of the genus *Lampanyctus. Bull. Bingham Oceanogr. Coll.* New Haven, vol. 2.

1934. Studies of Myctophinae in the Museum of Comparative Zoology. *Bull. Mus. Comp. Zool.* Harvard College, Vol. LXXVII, No. 2, May, 1934.

PETERS, W.

1864. Sitzung der physikalisch-mathematischen Klasse, 20 Juni. *Monatsb. Ak. Wiss.*, Berlin, 1864.

POEY, F.

1865. Repertorio fisico-natural de la isla de Cuba. Havana, 1865-1868.

RAFFAELE, FR.

1889. Note intorno alle specie mediterranee del genere *Scopelus. Mitth. Zool. Stat. Neapel*, 1889.

REGAN, C. T.

1916. Fishes. British Antarctic ("Terra Nova") Expedition, 1910, Nat. Hist, Rept. Zoology, Larval and Postlarval Fishes, Vol 1, 1914-1916.

RICHARDSON, J.

1844-48. Ichthyology of the voyage of H. W. S. "Erebus and Terror." London, 1844-1848.

ROULE, L. & ANGEL, F.

1930. Larves et alevins des poissons provenant des croisieres du Prince Albert 1st de Monaco. Resultats Campagnes Sci. Albert I. Prince de Monaco.

1933. Poissons provenant des campagnes du Prince Albert 1 de Monaco. Resultats des Camp. Sci. Sci. Monaco, Fasc. 86, 1933.

SANZO, L.

1918. Stylophthalmoides lobianco Mazzarelli e St. mediterraneus Mazzarelli sono le respettive forme larvali di Scopelus *caninianus* C. e. V. e Sc. *humboldti* Risso, R. Com. Talass. Ital. Venice. Contributo alla conoscenza dello sviluppo postembrionale negli. Scopelini Müller. Memoria 66, 1918.

SMITT, F. A.

1893-1895. A history of Scandinavian fishes, 2nd ed. Stockholm, 1893-1895.

STEINDACHNER, F.

1881. 1. Uber einige neue und seltene Meeres fische aus China.
11. Ichthyologische Notizen, V, 4, Uber

eine neue Scopelus und Monacanthus-Art aus China.

Ichthyologische Beitrage (XI). Sitz. Ber. Kais. Ak. Wiss. Wien, Vol. 83, Pt. 1, Vienna, 1881.

TANAKA, S.

1908. Descriptions of eight new species of fishes from Japan. *Annot. Zool. Japonenses,* Vol. 7, 1908.

1911. Figures and descriptions of the fishes of Japan. *Journ. Coll. Sci. Imper. Univ. Tokyo,* Vol. 4,

TÅNING, A. V.

1918. Mediterranean Scopelidae. Report Danish Oceanog. Exped. 1908-1910, Vol. 2, A 7, Copenhagen.

1928. Synopsis of the Scopelids in the north Atlantic. Vidensk. *Medd. Dansk. Naturh. Foren.,* vol. 86.

1932. Notes on the Scopelids from the Dana Expedition, I. *Ibid.,* vol. 94.

THOMPSON, W. W.

1916. Catalague of fishes of the Cape Province. Marine Biol. Rept., No. III, Prov. Cape of Good Hope. Cape Town, 1916.

TOWNSEND, C. H., & NICHOLS, J. T.

1925. Deep-sea fishes of the "Albatross" Lower California Expedition. *Bull. Amer. Mus. Nat. Hist.,* Vol. 52, Art. 1. New York, 1925.

VAILLANT, L.

1888. Expeditions Scientifiques du "Travailleur" et du "Talisman" pendant les années 1880, 1881, 1882, 1883. Poissons, Paris, 1888.

VINCIGUERRA, D.

1885. Appunti ittiologici sulle collezione del Museo Civico di Genova, VII, Sopra alcuni pesci nuovi del Golfo di Genova. *Ann. Mus. Civ. Storia Nat. Genova,* Ser. 2, Vol. 2, Genova, 1885.

WAITE, E. R.

1904. Additions to the fish-fauna of Lord Howe Island, No. 4. *Rec. Australian Mus.,* Vol. 5, Sidney, 1903.

WEBER, MAX

1913. Die Fische der Siboga-Expedition. Siboga-Expeditie, Monog. 57, Livr. 65. Leiden, 1913.

WEBER, M., & BEAUFORT, L. F.

1913. The fishes of the Indo-Australian Archipelago, Vol. 2. Leiden, 1913.

WEILL, R.

1926. Poissons abyssaux, à organes lumineux, du Détroit de Messina (démonstration). *C. R. Soc. Biol.,* Paris, vol. 94.

WINTHER, G.

1879-80. Prodromus ichthyologiae Danicae marinae. Fortegnelse over de i Danske farvand hidtil fundne fiske. *Naturhist. Tidsskrift,* Raekke 3, vol. 2. Copenhagen, 1879-80.

ZUGMAYER, E.

1911. Diagnoses des poissons nouveaux provenant des campagnes du yacht "Princess Alice" (1901-1910). *Bull. Inst. Oceanographique Monaco,* 1911.

NEW YORK ZOOLOGICAL SOCIETY

General Office: 630 Fifth Avenue, New York 20, N. Y.

OFFICERS

FAIRFIELD OSBORN, *President*
ALFRED ELY, *First Vice-president*
LAURANCE S. ROCKEFELLER, *Second Vice-president*
HAROLD J. O'CONNELL, *Secretary*
CORNELIUS R. AGNEW, *Treasurer*

SCIENTIFIC STAFF

General

JOHN TEE-VAN, *Executive Secretary*
JEAN DELACOUR, *Technical Adviser*
WILLIAM BRIDGES, *Editor and Curator of Publications*
CLAUDE W. LEISTER, *Education*

Zoological Park

LEE S. CRANDALL, *General Curator & Curator of Birds*
LEONARD J. GOSS, *Veterinarian*
CLAUDE W. LEISTER, *Associate, Mammals*
JOHN TEE-VAN, *Associate, Reptiles*
GRACE DAVALL, *Assistant to General Curator*

Aquarium

CHRISTOPHER W. COATES, *Curator and Aquarist*
ROSS F. NIGRELLI, *Pathologist*
MYRON GORDON, *Assistant Curator*
C. M. BREDER, JR., *Research Associate in Ichthyology*
G. M. SMITH, *Research Associate in Pathology*
HOMER W. SMITH, *Research Associate in Physiology*

Department of Tropical Research

WILLIAM BEEBE, *Director*
JOCELYN CRANE, *Research Zoologist*
HENRY FLEMING, *Entomologist*
WILLIAM K. GREGORY, *Associate*
GLORIA HOLLISTER, *Associate*
JOHN TEE-VAN, *Associate*
MARY VANDERPYL, *Associate*

Editorial Committee

FAIRFIELD OSBORN, *Chairman*

WILLIAM BEEBE
WILLIAM BRIDGES
LEE S. CRANDALL
JEAN DELACOUR
CLAUDE W. LEISTER
JOHN TEE-VAN